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FURTHER STUDIES ON THE STEM-ROT OF ABACÁ IN THE PHILIPPINES [1]

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TEN PLATES

In a previous paper,(3) stem-rot was reported serious in Silang, Cavite Province. Subsequent surveys show that it is also present in other parts of Cavite and in certain abacá sections of Camarines Norte, Camarines Sur, Albay, Sorsogon, Mindoro, and Davao.

Apparently the prevalence of abacá stem-rot is influenced greatly by prolonged drought, a condition that usually prevails in the highlands of Cavite during the dry season. Almost every year in Cavite, particularly during the hottest months, the disease causes considerable damage to plantations. This seldom occurs, however, in other abacá regions of the Philippines visited, evidently because in these places the rainfall as a rule is more or less uniformly distributed throughout the year.

Since the first appearance of the disease in 1931, studies of its occurrence on the different varieties of abacá have been carried on continuously up to the present writing. The results of our observations in Silang, Cavite, for the last two years, 1932 and 1933, show that the varieties Baluñganon and Putian are the most severely infected, each of them manifesting a yearly infection of almost 50 per cent. In many cases the disease causes the plants to fall down (Plate 1). The varieties Jolo, Tañgoñgon, Sinamoro puti, S. pula, Lawisid, Balunan, Maguindanao, and Punukan, are all affected also, but none of these succumb as readily as the Baluñganon or the Putian. The varieties Si-

[1] Read by the senior author before the Philippine Science Convention held in Manila, February, 1933.

nibuyas and Kinalabao are the least infected. Both of these varieties are native and already well adapted to Cavite conditions, whereas the others were obtained from different parts of the Philippines.

HOST RANGE

Abacá stem-rot was found also on bananas locally known as Butuhan, Saba, and Latundan. At its advanced stage, the disease may cause the plant to fall over (Plate 2). Recently Curzi(4) described a new species of *Helminthosporium* on Canary bananas in Italian Somaliland. The author names his fungus *Helminthosporium gibberosporum*. It has not been ascertained whether or not this organism is the same as the one causing stem-rot in the Philippines.

Subsequent intimate surveys showed that green fruits of Latundan, Lacatan, and Boñgolan sometimes, develop a decided necrosis on the tips and stalks, similar to the "black-tip" disease previously reported by Wardlaw(17). As will be shown later, this particular fruit rot is caused by the same organism responsible for the stem-rot of abaca.

SEASONAL OCCURRENCE OF THE DISEASE

To all appearances stem-rot is more serious during the dry season than during the wet season. It is interesting to note also, that it is more prevalent in young plantations, about 3 years old, than in the older ones. Field infections generally start about the latter part of December. From this time on, it spreads rapidly over the plantations and develops deep-seated necrosis on the stem, finally causing the plant to topple over. These symptoms are common in the field from March and April to early June. A little later, as the rains set in, the infection decreases considerably. Most of the vigorous plants on the hills that are slightly infected show signs of recovery and new shoots develop to take the place of the dead ones. From this time on the plantations look healthy until the beginning of the dry season of the following year.

THE CAUSAL ORGANISM

The causal organism was isolated as follows:

All the outer infected leaf-sheaths of the stem were removed, leaving only the innermost infected leaf-sheaths that bore a typical incipient lesion. From these tissues suitable square portions were cut, sterilized with mercuric bichloride solution (1:

1,000), washed in several changes of sterilized distilled water and then planted in corn meal or potato dextrose agar. The organism may be also isolated by transferring tufts of conidia or mycelial growths from sterile square sections kept in damp chambers under aseptic conditions. If any contamination occurs, the cultures obtained by this method can be purified by the single spore method.[2]

CULTURAL STUDIES

In order to study the cultural behavior of the fungus the organism was grown on potato dextrose agar, oat meal agar, abacá and banana substrates, steamed unpolished rice, and abacá and banana agar. The last two media were prepared by adding 18 grams agar to a liter of sap obtained by cooking, for about an hour, 200 grams of the chopped materials in a double boiler. The results of these studies are tabulated below.

TABLE 1.—*Showing the cultural behavior of the fungus on different media.*

Substrate.	Date planted.	Remarks.
Potato dextrose agar	December 11, 1931	Mycelium aërial, turns greenish to black in 4 days; covers substrate entirely in 5–6 days. Spores plenty.
Oatmeal agar	do	Mycelium dense but not decidedly aërial, turns greenish black in 6 days; covers substrate in 5 days. Spores plenty.
Abacá agar	do	Mycelium aërial, turns greenish black in 8 days. Spores plenty.
Banana agar	do	Mycelium aërial, growth abundant, turns greenish black in about 10 days. Spores few.
Abacá cylinder	do	Mycelium dense, turns greenish black in 10 days. Spores comparatively few.
Banana cylinder	do	Mycelium dense, growth more abundant than on abacá, turns greenish black in more than 10 days. Spores few.
Steamed rice 3 grams per 1 cc. water.	do	Growth comparatively poor, mycelium turns black in 12 days. Spores few.
Steamed rice 3 grams per 3 cc. water.	do	Growth of mycelium dense and abundant; turns greenish black in 5–6 days. Spores plenty.
Steamed rice 3 grams per 5 cc. water.	do	Do.

Table 1 shows that potato dextrose agar favored the best growth, followed respectively by oatmeal and steamed soft un-

[2] Keith, G. W., Simple technique for isolating single spore strain of certain types of fungi. Phytopath. 5 (1915): 266–267. Fig. 1.

polished rice prepared by adding 5 cc. of water to every 3 grams of rice in a test tube. Each of these media favored fair and luxuriant vegetative growth and uniform rate of sporulation. The plant substrates and the hard rice media showed poor growth, because they dried up too readily.

In general, in all the media, the cultures first form an abundant white aërial mycelium which later turns dark brown to fuscuous grey as the organisms grow old (Plate 7, figs. 1–2). Sporulation generally starts in four to six days, or as soon as the pheripheral portion of the culture has turned brown or dark. The color change is especially noticeable on potato dextrose agar and on oatmeal agar. In old age the mycelium settles down on the medium as a thick grey weft (Plate 7, figs. 3—4).

In our cultural studies it was observed that some slant cultures developed somewhat differently from others from the same batch. In some cases the medium turned slightly darker than in others. Quite often all subcultures from a spore-bearing culture did not sporulate normally as expected. Some produced only a few conidia, others developed no conidia at all (Plate 7, fig. 4). Microscopic mounts of these nonsporulating cultures showed the presence of dark hyphæ, and of a few conidiophores, but conidia were entirely absent. In order to find out the cause of this unusual change in growth habit, single-spore isolations were prepared from cultures producing a goodly number of conidia. From these isolations slant and plate cultures were made. It was observed that not all the subcultures produced conidia as expected. There were always a few without spores although they were all originated from the same spore culture. Later it was discovered in some of the plate cultures that the fungus exhibited a non-uniform vegetative growth. It was frequently found in some dishes that the mycelial growth was uneven, one portion exhibiting a fine submerged hyphal growth, the other portions consisting mostly of coarse aërial hyphæ. Cases of sectoring were often observed in many of the plate cultures (Plate 8, fig. 2). Finally it was discovered that the fine submerged mycelium generally gave rise to nonspore bearing cultures, while cultures originated from the coarse and aërial hyphæ almost always sporulated.

This phenomenon of sectoring was also observed by Sellschop(16) in a *Gloeosporium* and by Leonian(6) in *Phytophthora*. Whether or not this phenomenon in our cultures is a case of mutation, as Sellschop said, is not entirely proven.

Conidiophores.—The conidiophores are generally erect brownish to dark, septate and distinctly nodulose. They occur either singly or gregariously, their bases swollen and more or less united (Plate 5, figs. 1–8). The nodules or knots, resembling collars or rings, are darker than any other portions of the conidiophore. They are not definite in number, neither do they occur at regular intervals on the conidiophore. They appear at any point between the base and the tip of the conidiophore (Plate 5, figs. 1–8). The apical or terminal segment of the conidiophore is subhyaline, swollen or inflated into a knoblike structure, simulating the shape of a pestle (Plate 5, figs. 1–8). The conidiophores vary in size, especially in the cultures where they may acquire a considerable length due to the prolongation of their tips (Plate 5, figs. 4, 7, and 8). The growth of the conidiophore is continued simply by pushing out a branch from the swollen conidiophore head, usually at some lateral point on the surface (Plate 6, figs. 5–6). However, the other and seemingly more common method of conidiophore elongation is initiated by the upward growth of the cell just below the conidiophore head (Plate 6, figs. 1–4). This penultimate cell grows out into the clear space in the inflated conidiophore head, then swells up and fills the entire volume of the head. It then elongates further and ploughs its way through the thinnest portion of the apical cell, or the scar left behind by the falling away of the mature conidium. The branch is at first hyaline with a conspicuously vacuolated protoplasm, but later on, as it elongates further, it acquires the characteristic brown color of a typical conidiophore. It continues to increase in size and may finally bear a conidium. In nature the conidiophore ranges in size from 48 to 170 μ by 6 to 10 μ, and are generally from 1 to 9 septate.

Conidia.—Young conidia are hyaline and vacuolate. When mature they are smoky olive, straight or slightly curved, long or short, widest above the base, narrowing thence to a blunt point (basal end) (Plate 3, figs. 1–9). The base shows a dark marking, the point formerly attached to the conidiophore head. The tip and the base of the conidium are subhyaline and thin-walled (Plate 3, figs. 1–9). A rostrate prolongation may arise either from the tip or from the base of the conidium (Plate 3, figs. 6, 8 and 9), or else two prolongations are developed from either end at the same time (Plate 3, figs. 8).

A conidium, while still attached to the conidiophore, may send out from its basal cell a hypha that elongates downward and pierces the conidiophore head. This was excellently illustrated by Wardlaw(17). A conidium may also develop a hypha-like structure within its body which is accomplished by the elongation of the last cell towards the apex of the conidium. Later on, the elongated cell develops septa, the number depending upon the length of the hyphal structure. These observations corroborate the findings of Wardlaw(17).

Many of the conidia germinate by producing two polar germ tubes, each originating from the subhyaline thin-walled regions on either end (Plate 4, figs. 10, 11 and 14). Some may germinate also by producing three germ tubes, one originating from a side of the conidium in addition to the two from each end (Plate 4, fig. 12). Sometimes a mature conidium may have a continued growth at its apex, which later on develops into a short conidiophore that bears a terminal young hyaline and non-septate conidium (Plate 4, fig. 13), which upon maturity becomes smoky olive and several septate.

Apparently temperature and perhaps light influence the development, size, and shape of the conidia. The same observation was made by Nisikado(9) on *Helminthosporium maydis* and *H. turcicum*. The abacá *Helminthosporium* vegetates slowly and sporulates somewhat sparingly at low temperature (15° C–20° C). Under this condition the majority of the conidia are crescent-shaped or slightly curved (Plate 3, figs. 6–9), ranging in size from 25–59 μ × 8–12 μ and generally 6–14 septate. Above 20° C more conidia are produced which generally appear less curved or twisted. (Plate 3, fig. 6), their size varies from 33–137 μ × 13–17 μ and the septation is 15–20. With further rise in temperature (27° C–30° C), they increase considerably in number, exhibiting little or no curvature. Their size ranges from 59–144 μ × 9–15 μ and the septation, 6–14. Under ordinary laboratory conditions (27° C–30° C) or at slightly higher temperatures (29° C–37° C) which closely approach the air temperatures during summer months in the Philippines, the conidia are mostly straight-cylindrical, 28–80 μ × 9–15 μ in size and generally 7–8 septate.

INOCULATIONS ON DIFFERENT VARIETIES OF ABACÁ AND BANANA

Reciprocal cross-inoculations were conducted in the laboratory and the greenhouse on bananas known locally as Butuhan,

Saba, Latundan, Lacatan, and Boñgolan, and the two susceptible abacá varieties, Baluñganon and Putian. The inoculation work was further followed in Silang, Cavite on all varieties of abacá present at the Bureau station there.

Laboratory and greenhouse inoculations.—In the laboratory, green sound fruits kept in damp chambers were employed for inoculation studies. The fruits were disinfected on the outside with mercuric bichloride solution (1:1,000), and washed with sterile distilled water before they were inoculated with abacá organism. Four fruits of a kind were placed in every chamber, two of which were injured before inoculation. Controls were maintained in each case. Greenhouse inoculations were made mostly on living abacá and bananas. The abacá *Helminthosporium* was used on the bananas and the banana *Helminthosporium* on the abacá.

The results of the studies showed that Boñgolan and Lacatan fruits exhibited the characteriestic browning symptoms after four to five days, the Saba and Latundan two days later. The lesions were irregular and slightly sunken and resembled those found in nature. Fuscuous grey moldy tufts of spores of *Helminthosporium* were evident on the inoculated fruits but not on the controls. Later, when the fruits became over-ripe and almost disintegrated, *Gloeosporium* contaminations set in. In the greenhouse the inoculations were all positive after four or five days. The lesions on the abacá and bananas were closely similar to each other and exactly identical with those found in nature. The inoculum was successfully recovered from all the infected materials.

Field inoculations.—Extensive inoculations were undertaken at the Abacá Experiment Station, Silang, Cavite, during the dry and the wet seasons. Healthy suckers about a year and a half old, of all the different varieties of abacá grown at the station, were used. Four-to-five-day-old slant cultures of A[3] and B[4] organisms were used as inoculum. The old dried outer leaf-sheats were removed from the plants. After pricking the inner portion of the stem, the organism was applied by means of a needle. Wet pieces of cotton were tied on the inoculated stem to prevent the organism from drying or from being washed

[3] A abacá. [4] B banana.

down by rains. The inoculum was also applied by inserting between the leaf-sheaths without causing injury. This work was discontinued because insects and rains often interfered with it. Corresponding controls were maintained in all cases. The results are given in Table 2.

The banana inoculations in the greenhouse were repeated later in our experimental plots, in Singalong, Manila. The varieties available were Butuhan, Lacatan, and Latundan. Both the abacá and banana organisms were used for inoculum. Positive results were obtained in all cases, the symptoms manifested being identical with those of natural infections occurring on abacá and banana.

TAXONOMY

In our preliminary report, the causal organism of the stem-rot of abacá in the Philippines was tentatively placed under the genus *Helminthosporium*. From that time on, the work was followed up closely by carrying on intimate morphological and inoculation studies of the fungus. Exhaustive literature work on the subject as well as extensive surveys of the distribution of the disease in the Islands were undertaken. In October, 1932, Wiltshire of the Imperial Mycological Institute, England, requested type specimens and cultures of our organisms for comparison with a congeneric form already described by Wardlaw(17) on bananas in Bermuda. Cultures of the organisms isolated from abacá and banana were sent to him. Mr. Wiltshire identified our fungus as *Helminthosporium torulosum* (Syd) Ashby and regarded it as the same species as that on the banana.[5]

According to literature, the fungus was first reported and described by Ashby(2) as causing the leaf and fruit spots of Gross Michel banana in Jamaica. Later it was reported by investigators in other tropical countries. It was successively pointed out by Ogilvie(12, 13, 14, and 15) as an active fruit parasite on Dwarf, Canary, or Cavendish (*Musa cavendishii* Lamb) in Bermuda. In Trinidad Wardlaw(17) not only found it on the Bermuda varieties already named but also on Lacatan varieties. It has been also noted in Peru(1) and quite recently in India(8.) In the Philippines *Helminthosporium torulosum* (Syd) Ashby principally attacks abacá, causing deep-seated necrosis on the

[5] We are much indebted to Mr. S. P. Wiltshire, Assistant Director of the Imperial Mycological Institute, for identification of our fungus.

TABLE 2.—*Showing the results of dry season inoculations.*

[NOTE: + slight; ++ moderately severe; +++ severe; ++++ very severe]

Variety name.	Degree of infection.			
	First series.		Second series.	
	Abacá oganism.	Banana organism.	Abacá organism.	Banana organism.
Balunan	++++	+++	++++	++++
Do	----------	----------	++++	++++
Do	----------	----------	++++	++++
Balunganon	++++	+++	++++	+++
Jolo lambutin	+++	++++	+++	+++
Do	+++	+++	++	+++
Jolo tigasin	----------	----------	++	+++
Do	----------	----------	++	+++
Do	----------	----------	++	+++
Kinalabao	++	++	++	++
Lawisid	+++	++	++	+++
Do	----------	----------	++	+++
Do	----------	----------	++++	++++
Do	----------	----------	++	+++
Do	----------	----------	++	+++
Maguindanao	++++	++++	+++	++
Do	++++	++	++	++
Do	----------	----------	+++	++
Do	----------	----------	+++	++
Do	----------	----------	++	++
Punukan	++++	++++	++++	+++
Do	----------	----------	++++	++
Do	----------	----------	+++	+++
Putian	+++	++	+++	+++
Do	----------	----------	+++	+++
Do	----------	----------	++	+++
Sinibuyas	+	++	+	++
Do	----------	----------	+	+
Do	----------	----------	+	++
Sinamoro pula	++++	+++	+++	+++
Do	++++	+++	+++	+++
Do	----------	----------	++++	+++
Do	----------	----------	+++	++
Do	----------	----------	++++	+++
Sinamoro puti	++++	++++	++	+++
Do	----------	----------	++++	++
Do	----------	----------	++++	+++
Tangongon	----------	----------	++	++++
Do	----------	----------	+++	++
Do	----------	----------	+	++
Canton	+	+	+	+

stem. Sometimes it also occurs on the stem of Butuhan and Saba; occasionally on fruits of Bongolan, Lacatan and Latun-

TABLE 3.—*Showing the results of wet season inoculations.*

[NOTE: + slight; ++ moderately severe; +++ severe; ++++ very severe]

Variety name.	Degree of infection.			
	First series.		Second Series.	
	Abacá organism.	Banana organism.	Abacá organism.	Banana organism.
Balunan	+++	+++	++++	+++
Balunganon	+++	+++	+++	+++
Jolo	++	+++	++	+++
Kinalabao	++	++	+	+++
Lawisid	+++	+++	+++	++
Maguindanao	+++	++	++	+++
Punukan	+++	++	++++	++
Putian	++	++	+++	+++
Sinibuyas	++	++	++	++
Sinamoro pula	+++	++	++	+++
Sinamoro puti	++	+++	++	++
Tangongon	+++	+++	++++	++
Canton	+	+	+	+

dan. It produces on the tips of green fruits brown to black, moldy, sometimes cracked, lesions, giving an unsightly appearance to the fruits and considerably lowering their market price.

THE INFLUENCE OF CERTAIN CONDITIONS OF THE DEVELOPMENT OF THE DISEASE

TEMPERATURE RELATION

According to intimate field observations, the severity of stem-rot is greatly influenced by temperature, moisture, and the vitality of the plant itself. This was checked up in the laboratory by carrying temperature relation experiments which were repeated three times.

The experiment consisted of plate cultures prepared as follows: Sixteen petri dishes of uniform size were filled with equal amounts of melted potato dextrose agar. These were inoculated with equal bits of inoculum and incubated, viz.; The first four dishes were placed at 15°C. to 20°C.; the second, at 25°C. to 27°C.; the third four at 27°C. to 30°C. and the last four at 29°C. to 37°C. The rate of growth was noted daily for six days from 6 a. m. to 6 p. m. The average growth from the four dishes placed under one set of conditions was taken as the increase in growth for that particular set of conditions.

In order to obtain the desired temperatures, the following devices were employed. For the first batch of dishes an ordinary ice box was used. The range of temperature in the box was kept down by placing the dishes in a beaker, immersed in a larger vessel containing lumps of ice and common salts. The next batch were placed in the laboratory, but the temperature was kept lower than that of the room, by immersing the rack holding the dishes in a bath into which water was made to flow continuously by means of an inlet tube attached to the faucet of the sink. The next batch was placed in an incubator which was previously adjusted to the temperature desired. This last set was supplemented by keeping a few petri dishes outside the laboratory where the temperature ranges were almost the same as those in the incubator.

It was obvious that to carry out the experiment properly, constant vigilance was necessary. Although it was apparently impossible to keep the temperatures exact for lack of adequate apparatus, the temperature in each set of conditions was well within the range of those given above. The results of the experiment are given in Table 4.

TABLE 4.—*Showing relation of temperature to the growth of the fungus.*

Temperature degrees.	Total measurements for a six-day period (in mm).				Total growth (in mm).	Average growth (in mm).
	Dish No. 1.	Dish No. 2.	Dish No. 3.	Dish No. 4.		
15°C–20°C	19.0	18.0	14.5	13.0	64.50	16.12
25°C–27°C	35.0	37.0	39.0	33.0	144.00	36.00
27°C–30°C	30.0	33.0	27.0	28.0	118.00	29.50
29°C–37°C	19.0	16.0	18.5	18.0	71.50	17.90

Between 25°C. and 27°C. the fungus produced the greatest amount of mycelial growth and a goodly number of conidia. In the temperature range of 27°C. to 30°C. the increase in growth was fair and the conidia were numerous, plump, and not so conspicuously curved. However, with a further rise in temperatures (29°C.–37°C.), growth decreased considerably, a little more than that being observed at the minimum temperatures (15°C.–20°C.). Although under the maximum temperature the vegetative growth was somewhat arrested, sporulation was normal as shown by all the cultures kept under these conditions. This finding has a significant bearing upon the observa-

tions in the field. Apparently the fungus is not so adversely affected by the weather conditions that prevail in the Philippines during dry season, whereas the plants will be greatly weakened under the same conditions. At high temperatures, which approach the maximum for certain places in the Philippines during dry season, the fungus develops a fairly good amount of conidia in cultures.

The results as tabulated above show that the greatest increase in the growth of the fungus occurred between 25°C. and 27°C. Apparently the optimum temperature of the fungus lies between these two points. These findings closely corroborate those of Wardlaw and McGuire(18) who report that the normal rate of growth of *Helminthosporium torulosum*, including the other banana fruit-rot organisms, occurs between 25.6°C. and 27.8°C. In this connection it may be interesting to note also that many species of *Helminthosporium*, as reported by various investigators,(5, 7, 9, 10, and 11) show optimum temperature requirements well within the range of the figures mentioned above.

In the table it is further shown that the fungus does not develop rapidly in the ice box which registered a range in temperatures, 15°C. to 20°C. Under this condition the vegetative growth was not only scanty but conidia were few, besides being narrow, long, and crescent-shaped or twisted. Again this finding conforms with the observations of Wardlaw and McGuire(18) who state that the growth rates of the organisms causing fruit blemishes and rots during storage, *Helminthosporium torulosum* included, were materially reduced when subjected to cool temperatures (53°F. to 55°F. or 11.7°C. and 12.8°C., respectively).

MOISTURE RELATION

The effect of moisture on the development of the fungus was studied repeatedly in the laboratory. The experiment consisted of inoculating samples of air- and oven-dried soils in petri dishes, containing different percentages of moisture,[6] as follows:

(*a*) Two dishes containing air-dried soil. Duplicated by oven-dried soils.

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[6] Approximately 800 grams sandy loam soil were heated in an electric oven. After the constant weight was obtained, the soil was divided into six 100-gram samples, from which the desired amounts for inoculation were obtained. Then the amount of water needed in each case was added, i. e., the sample containing 15 per cent moisture contains 15 cc water; 20 per cent sample, 20 cc water, etc.

(*b*) Two dishes containing 5 per cent moisture.
(*c*) Two dishes containing 10 per cent moisture.
(*d*) Two dishes containing 15 per cent moisture.
(*e*) Two dishes containing 20 per cent moisture.
(*f*) Two dishes containing 25 per cent moisture.
(*g*) Two dishes containing 50 per cent moisture.

Inoculations were made in duplicates or in pairs, organisms A and B respectively being used in each case. The dishes were placed in the laboratory for daily observation. A few days after inoculation, hyphal ramification was noted in samples containing 5 per cent, 10 per cent, 15 per cent, 20 per cent and 25 per cent respectively. This was shown by the apparent development of a dirty white weft of mycelium between the particles of soils. No growth was observed in air-dried, or oven-dried soils, or in the samples having 50 per cent moisture. Apparently the air and oven-dried soils lack the amount of moisture necessary for germination, whereas the sample containing 50 per cent moisture is too wet for the fungus. Apparently, the organism thrives only in soils that are neither very dry nor too saturated with moisture.

LONGEVITY AND VIABILITY OF SPORES

Experiments to determine how long the organism could stand desiccation without losing its vitality were conducted in the laboratory and in the field. From cultures on potato dextrose agar, oatmeal agar, and abacá and banana cylinders kept under room temperature (27°C. to 30°C.), transfers were made on fresh potato-dextrose agar, weekly for the first month, twice the next month, and only once a month for the succeeding months. The experiment lasted five months. It was found that the fungus could stand desiccation in the laboratory for at least four or five months. Unless the media were completely hardened and dry, subculturing was possible. It seems not unlikely that the fungus behaves similarly in the field as indicated by making successful soil inoculation in the laboratory. This observation pointed to possibility of the fungus spending a considerable part of its life cycle in the soil, provided sufficient moisture is present therein.

Experiments to find out if the fungus ordinarily spends a part of its life cycle in the soil were carried out in the field. Indirectly this experiment was intended as a check for the soil

moisture experiment. Soil samples were obtained from different sources as follows:

(*a*) From a pit for dumping diseased plants.
(*b*) From the base of an infected plant.
(*c*) From the base of a healthy plant.
(*d*) From a space between diseased hills.
(*e*) From a space between healthy hills.

From each soil sample equal amounts were taken and placed in vessels containing distilled water. After stirring the mixture thoroughly, the soil particles were filtered off through clean, fine-meshed cheese-cloth. The filtrates were transferred separately into four sterile petri dishes into which melted agar was poured. The dishes were incubated at 27°C. to 30°C. Obviously contaminations were present, but only *Helminthosporium torulosum* is considered here. The results of this experiment are summarized as follows:

1. Sample A—Conidiophores and conidia of *Helminthosporium torulosum* present.
2. Sample B—Conidiophores and conidia of *Helminthosporium torulosum* present.
3. Sample C—No conidiophores and conidia.
4. Sample D—Conidiophores and conidia present.
5. Sample E—Conidiophores present. This was rather unexpected. Perhaps the soil had been previously contaminated.

According to the results of this experiment, *Helminthosporium* spores are present in the soil but are more likely to occur near infected plants. In order to determine the viability of the spores found in the soil, two susceptible varieties, Baluñganon and Putian, were planted in soils supposed to be infected. Ten suckers of Baluñganon and Putian, respectively, were selected. They were planted in such a way that on either edge of the dump-pit one sucker of each variety was planted. All the other suckers were set in the pit in three rows, alternating Baluñganon and Putian in order that each variety might be supplied uniformly with the fungus spores.

Observations showed that many of the plants in the pit rotted and died a few weeks after planting. Perhaps the death of the plants was caused mostly by the heat of decomposition. However, it was also apparent that the few plants that survived the heat showed symptoms of stem-rot a few months after. Two of the plants on the edges of the pit manifested stem-rot also.

Evidently the pit served as a source of inoculum. Insects (ants), wind, and rain splashes might have carried the spores to the plants. These agencies have already been proved as carriers of spores [7] in an experiment conducted in the field.

DISCUSSION

Stem-rot is a serious disease of abacá as it often renders the stalk totally unfit for stripping. If slightly affected stalks are stripped, some fibers are found to be deep purple at the point where the infection occurred. The discolored portion ranges in length depending upon the size of the lesion on the leaf sheath. The disease usually prevails in certain highland towns of Cavite, but has never been observed so serious in the Bicol Provinces, Mindoro and Davao. Apparently the disease is largely influenced by weather conditions. It is especially favored by a prolonged drought, a prevalent condition in Cavite during the dry season but seldom true of the Bicol Provinces, Mindoro and Davao, where rainfall is more or less uniformly distributed throughout the year.

The observations in the field tallied with our studies in the laboratory. While as a rule the fungus requires a certain amount of moisture for its development, as shown by the results of cultural studies, the life of its host in the field depends far more upon moisture, as indicated by the marked effects of abundant rain on the vigor of the plants. The predisposition to stem-rot is lessened to a great extent by a well distributed rainfall throughout the year. Very likely, under this condition the plants have more chances of outgrowing the parasite.

The optimum temperature for the fungus lies between 25°C. and 30°C. Temperatures outside this range, either above or below, considerably retards the growth of the organism. Apparently these findings bear some relation to the conditions obtaining in the field. From the partial data given by the Weather Bureau for the years 1931, 1932, and part of 1933,[8] the average air temperature in Silang, Cavite, is generally lower than that of the Bicol regions and Davao. Conversely, it was noted also that the average monthly rainfall in the latter places are greater and more nearly uniform throughout the year than in the former.

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[7] Spore catching experiments were conducted in the field by exposing petridish cultures around infected as well as healthy plants.

[8] As per data compiled by the Weather Bureau for the years 1931 (complete), 1932 and 1933 (incomplete) . . .

From temperature-relation studies conducted in the laboratory it is apparent that the weather conditions in Cavite approach more closely the optimum requirements of the fungus than either the Bicol regions or Davao, where extensive abacá fields are found, and it is therefore to be expected that stem-rot be more prevalent in the former than in the latter. Whether or not the fungus and its host have the same optimum temperature and moisture range, extreme heat is the more damaging to the plants as far as the outbreak of the disease is concerned.

Experiments showed also the resistance of the fungus to desiccation for a period of several months. Apparently the fungus can spend a part of its life cycle either in desiccated tissues or in the soil, provided moisture is not entirely lacking. Perhaps the organism lives both on the host and in the soil throughout the year, but persists more in the plant as soon as the soil becomes too dry. Such a situation naturally augments the occurrence of the disease in the field during the dry season.

SUMMARY

1. Stem-rot is a serious disease of abacá in the highland towns of Cavite, but is not so grave in other abacá districts surveyed in the Philippines. It appears as deep-seated necrosis on the stem of the plant causing it to break. It also occurs on the stems of certain bananas, on fruits of such varieties as Latundan, Lacatan, and Bonggolan, where it causes brown to black necrosis on the "finger" tips or on the "finger-stalk".

2. Prolonged dryness favors the disease, largely as a result of the much weakened condition of the plants. A uniform rainfall throughout the year puts vigor in the plants and lessens their predisposition to stem-rot.

3. *Helminthosporium torulosum* (Syd) comb. nov. Ashby, is in constant association with stem and fruit necrosis on abacá and bananas respectively. The pathogene has been successfully used in reciprocal cross-inoculations on abacá and bananas in the laboratories, in the greenhouse, and in the field.

4. The optimum temperatures of the fungus seem to lie between 25°C. and 30°C. Below 25°C. and above 30°C., the growth becomes slow, showing that the minimum and maximum temperatures, respectively, lie at these two points. Ordinarily, during its most active stage, the fungus is in constant association with the living host, but during adverse conditions the pathogene may winter over in dried desiccated tissues and may persist in the soil if sufficient moisture and abacá refuse are present.

5. The disease may be reduced partially by constant roguing of diseased plants, supplemented by irrigation during prolonged drought. Perhaps planting the less susceptible varieties, or else selecting and developing a desirable strain from the local species rather than importing many different varieties, will minimize the disease in the field. The growing of efficient shade trees, especially in high arid places, will prevent rapid baking or drying of the soil which otherwise causes the weakening of plants and increases predisposition to stem-rot. This practice has been followed in Cavite and to some extent in Mindoro, Laguna, and in the Bicol Provinces, but not in Davao.

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ILLUSTRATIONS

Plate 1

A photograph of diseased abacá plants of Baluñganon variety about 4 years old, taken at the Abacá Experiment Station, Silang, Cavite. Note the dried affected outer leafsheaths dropping down the base of the stem. The size of the stem has been considerably decreased as a result of the death of the outer leafsheaths. The remaining inner portion of the stem show young lesions indicated by arrows. Photographed by the Department of Agriculture and Commerce.

Plate 2

A photograph of diseased banana plants of Butuhan variety taken in the yard of the Bureau of Animal Industry, Pandacan, Manila. Note the dried outer leafsheaths dropping to the ground showing the typical symptoms of the disease as indicated by several white arrows. They are identical with those on the abacá (see Plate 1). Photographed by the Department of Agriculture and Commerce.

Plate 3

1– 5. Conidia from host. Note their size and form. Drawn with the aid of camera lucida. × 750.

6– 9. Conidia from cultures incubated at different temperatures. Note the influence of temperatures on the forms and shapes of conidia. Note also the proliferation in Figs. 6, 8, and 9 simulating that of young germ tube. Drawn with the aid of camera lucida. × 820.

6. A conidium from cultures kept under laboratory conditions.

7– 9. Conidia from cultures kept under temperature conditions slightly lower than that of the ordinary laboratory room.

Plate 4

10–14. Germination of conidia. Drawn with the aid of camera lucida. × 820.

10–11. Conidia showing the development of two germ tubes one from each end.

12. A conidium showing the formation of three germ tubes, one from each end of the conidium and another from its side. The tube is already somewhat fully developed, showing numerous branches.

13. A conidium with a short fully developed conidiophore that has given rise to a young hyaline non-septate conidium.
14. A conidium germinated from a hanging-drop culture of potato dextrose agar. Note the constricted form of the germ tubes, both at the basal and apical portions of the conidium. The twisting was due perhaps to the hard contact with the slides and cover glass.

PLATE 5

1– 8. Conidiophores of different sizes. All taken from host except those in figs. 4, 7 and 8. Note the characteristic shapes, particularly the nodules or rings on the conidiophores. The tips are hyaline and bulging, simulating the shape of a pestle. Drawn with the aid of camera lucida. × 700.
1. Two conidiophores from host connected at the base. The one on the left bears a conidium. Figs. 1, 2, 3, 5 and 6 are all from host.
4, 7 and 8. Conidiophores from cultures. Compare their shapes and forms with those from host. The conidiophores from cultures are generally longer than those from host due to prolonged growth of conidiophores. Fig. 7. Showing the branching of conidiophore.

PLATE 6

1– 6. Germination of conidiophores in a hanging-drop culture. Drawn with the aid of camera lucida. × 530.
1– 2. Conidiophores at their early stage of germination. Note the origin of the germ tube.
3. Conidiophore at a more advanced stage of germination. Note the numerous hyphal development from the lower end of the tube.
5– 6. Early stages of germination. Note the origin of the germ tube. The hyphae are developed laterally from the conidiophore head. Compare this method of germination with that shown in figs. 1 and 2.

PLATE 7

1. A pure slant culture of *H. torulosum* on abacá grown on potato dextrose agar about 8 days old.
2. A pure slant culture of *H. torulosum* on banana grown on potato dextrose agar about 8 days old.
3. A culture of *H. torulosum* from abacá about 42 days old. This culture produces a goodly number of spores.
4. A pure culture of *H. torulosum* from abacá about 42 days old. This culture showed no spores. (Photographed by the Department of Agriculture and Commerce.)

PLATE 8

1. A pure plate culture of *H. torulosum* from abacá, 25 days old. This culture originated from a spore-bearing slant culture. (Photographed by the Department of Agriculture and Commerce.)
2. Another pure plate culture of *H. torulosum* from abacá about 25 days old, showing a case of sectoring. Note the unevenness of the growth of mycelium; a certain portion is somewhat submerged whereas the other, aërial. This culture is taken from a non-spore bearing slant culture. (Photographed by the Department of Agriculture and Commerce.)

PLATE 9

1. A ten-day old pure plate culture of *H. torulosum* on abacá.
2. A ten-day old pure plate culture of *H. torulosum* on banana. (Photographed by the Department of Agriculture and Commerce.)

PLATE 10

1. A 25-day old pure plate culture of *H. torulosum* on abacá.
2. A 25-day old pure plate culture of *H. torulosum* on banana. (Photographed by the Department of Agriculture and Commerce.)

PLATE 1.

PLATE 2

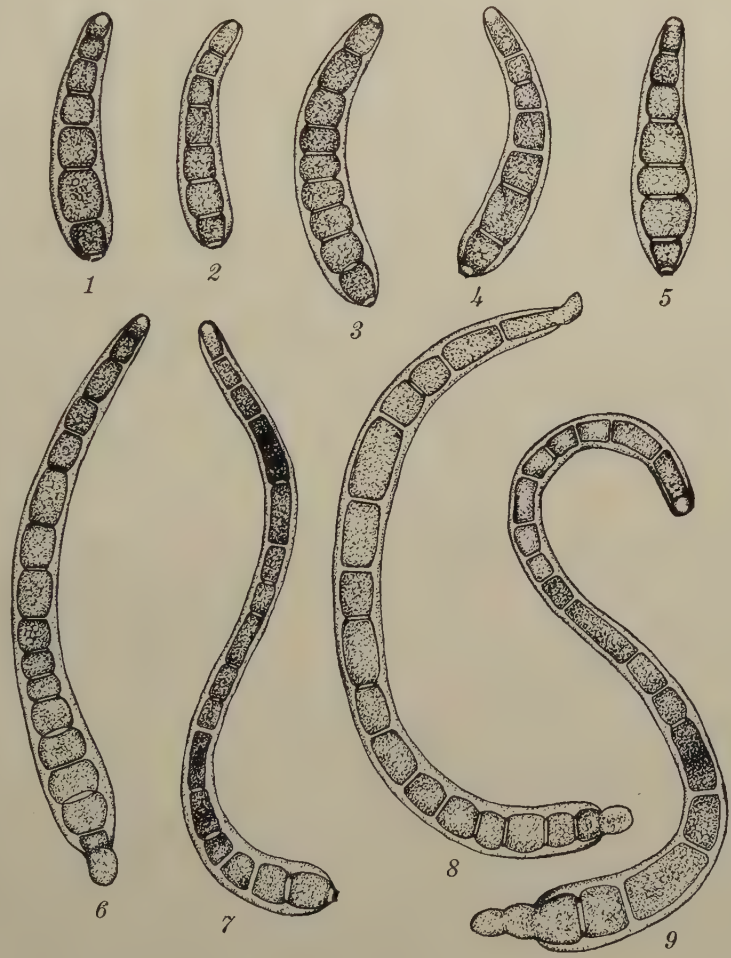


PLATE 3.

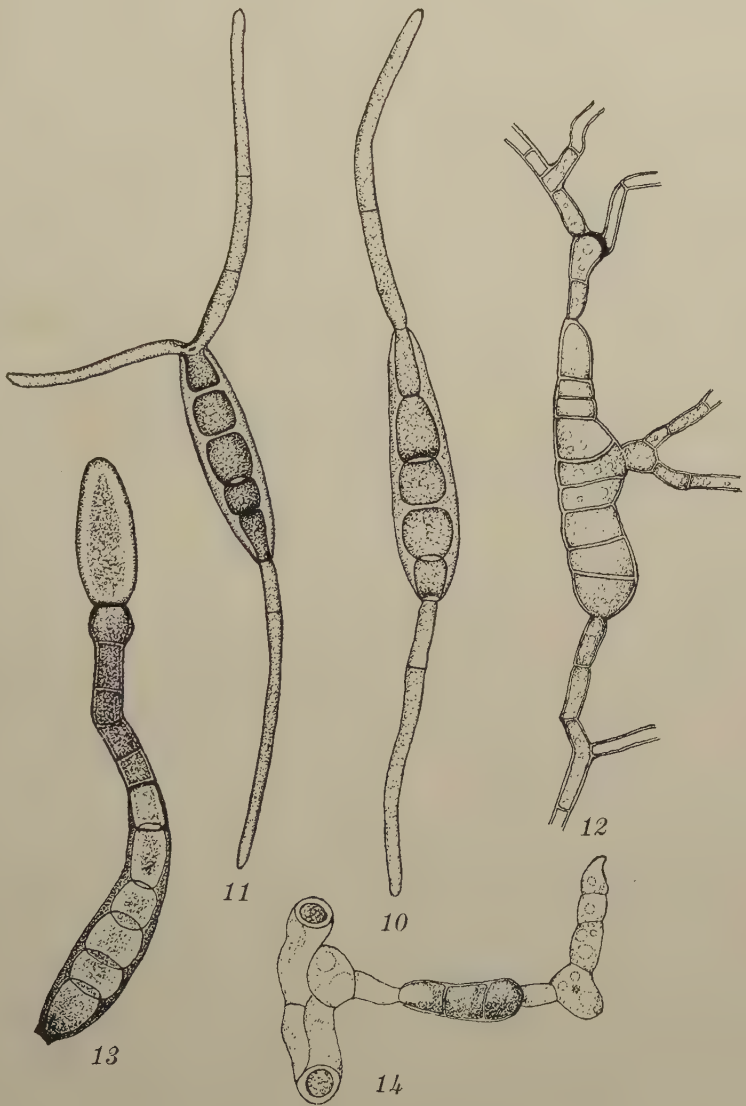


PLATE 4.

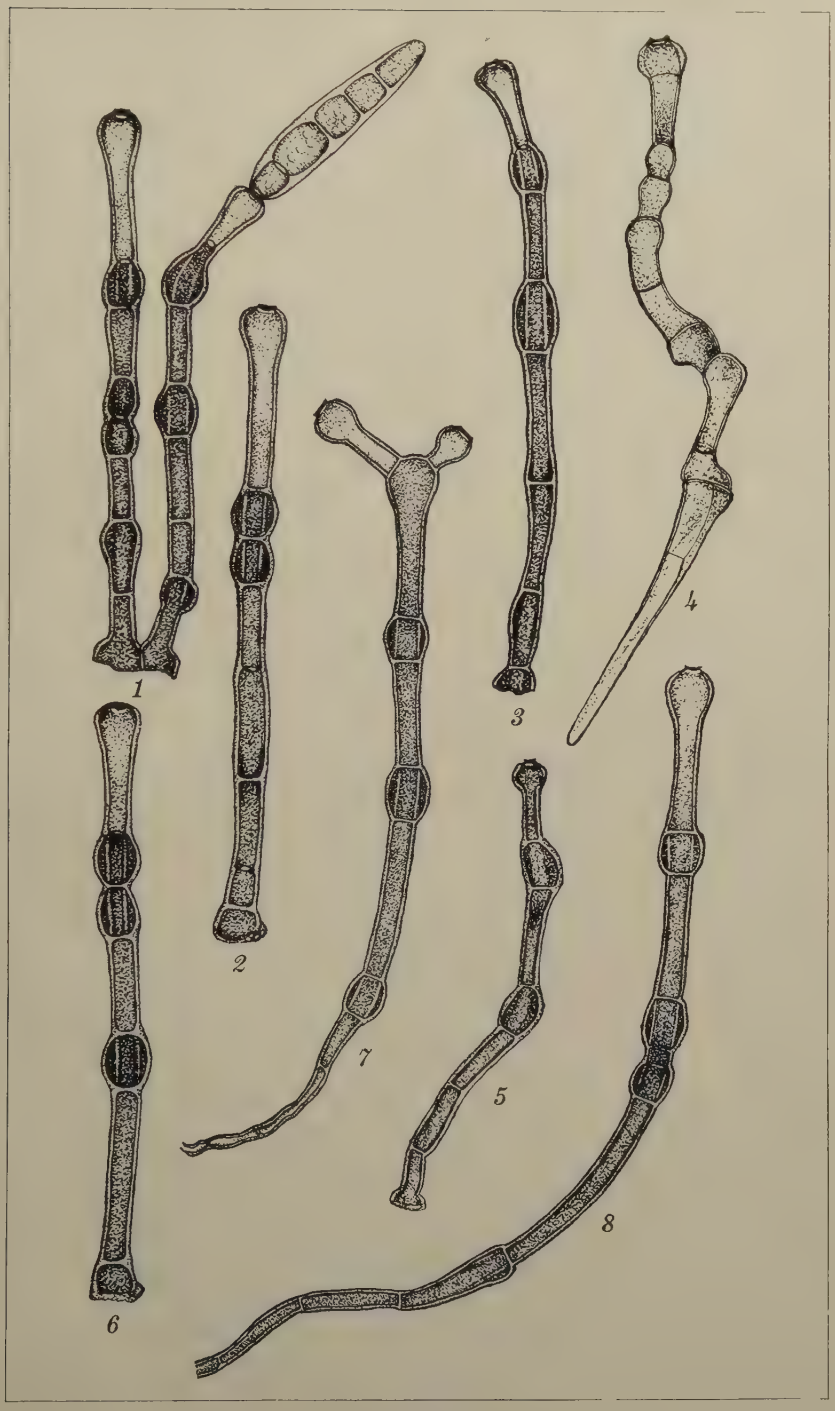


PLATE 5.

1

2

3

4

5

6

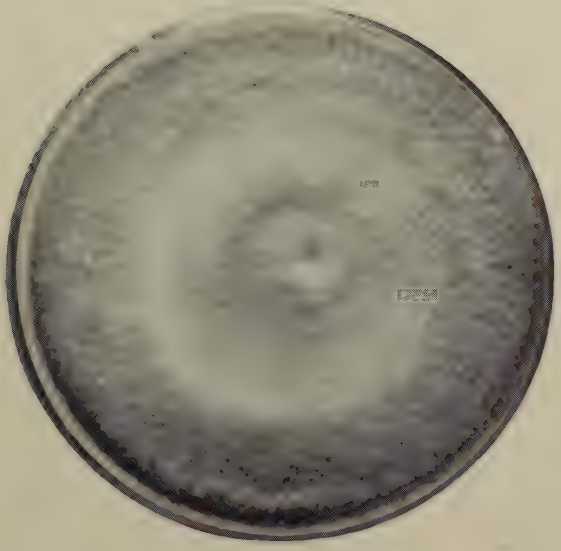
PLATE 6.

Abaca
9-20-33
Banana
9-20-33
Abaca
8-17-33
With Spores
Abaca
8-17-33
No Spores
1
2
3
4

PLATE 7.

PLATE 8.

PLATE 9.



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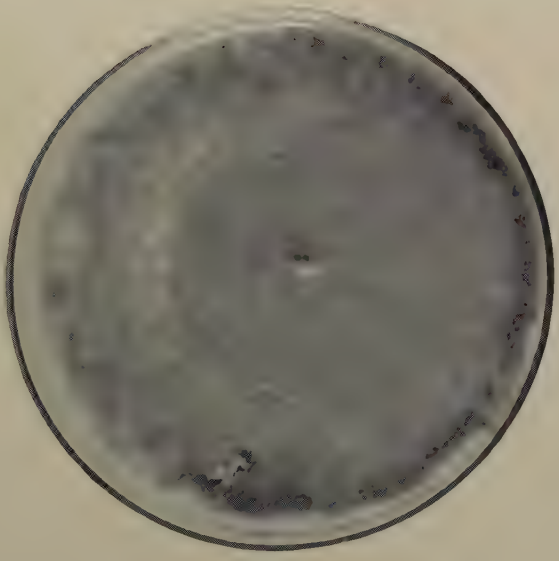

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PLATE 10.

IRISH POTATO CULTURE IN THE PHILIPPINES

By PEDRO A. RODRIGO

Of the Bureau of Plant Industry, Manila

FOUR PLATES AND ONE TEXT FIGURE

Among the semitemperate vegetable crops introduced into the Islands, the Irish potato, *Solanum tuberosum* L. promises to be an important staple crop in the highlands. The demand for potatoes is very great in the Islands. Our annual importation during a ten-year period (1921–1930) was 9,240,700 kilograms, with an average value of 651,170 pesos.[1] In 1931 and 1932, the average annual importation of this staple was 12,579,821 kilograms, an increase of more than 36 per cent over the average of the preceding ten-year period.

According to statistical figures for 1932,[2] the area under cultivation for Irish potato in the Philippines was only 203 hectares distributed in 22 provinces, with Lanao, Oriental Negros, Nueva Vizcaya, and the Mountain Province in the lead. The total production for the same year, 306,100 kilograms, is rather insignificant when compared with the importation of the same year. The low production may be explained by the fact that the variety grown was mostly the "native" or Spanish potato, a small-tubered variety. To meet the present demand of the Islands, it will be necessary to grow from 2,500 to 5,000 hectares of Irish potato every year. While this area may appear comparatively small, it would enable the country to earn an annual income of over half-million pesos and would furnish livelihood for a considerable number of farmers and gardeners.

Studies conducted by the Bureau of Plant Industry show that the Irish potato can be grown commercially in the higher regions of the Philippines. For the purpose of encouraging farmers to raise potatoes in regions where they can be cultivated, some practical pointers on the growing of this crop under Philippine conditions are here given.

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[1] Data furnished by the Bureau of Customs, Manila.

[2] Statistical Handbook of the Philippine Islands, 1932. Department of Agriculture and Commerce, Bureau of Printing, Manila.

CLIMATIC AND SOIL REQUIREMENTS

Climatic requirements.—The Irish potato is a crop of temperate countries, but it can be grown in tropical countries at high elevation. In the Philippines, potato grows best at elevations ranging from 1,000 to 5,000 feet above sea level. It will also produce a fair crop at lower altitudes, provided the climate is cool. It does well in Baguio, and Trinidad Valley, Mountain Province, where it is being produced commercially on a limited scale. Other regions where the crop is known to grow are Lipa, Batangas, Upper Lanao, and Bukidnon in Mindanao, Nueva Vizcaya in the Cagayan Valley, the highlands of Negros Island, and Cervantes and Upper Tagudin in Ilocos Sur. Undoubtedly, there are many other places in the Philippines where the soil and climatic conditions are similar to those enumerated above. (Plates 1 and 2.)

In the Philippines, the Irish potato grows and gives the best crop when planted at the beginning of the dry season. Too much rain is detrimental to the proper development of the plant, and if it develops at all, it does not produce good tubers. In Panubigan, Negros, however, a good crop of potato can be raised during June, July, and August.

Soil requirements.—Potato, like any other root crop, requires a rich and friable loam soil for proper development. Alluvial, sandy, and silt loam soils are very good for potatoes. In general, light soils produce better crops, both in quantity and in appearance, than heavy soils. Light soils, however, are generally deficient in plant food, and less retentive of moisture.

The soil should have a liberal supply of organic matter. This not only adds plant food elements but also renders the soil a better medium for the development of beneficial bacteria. The supply of organic matter in the soil may be maintained by the judicious use of farm manures and the plowing under of green manure crops and crop residues.

VARIETIES ADAPTED TO PHILIPPINE CONDITIONS AND THEIR INTRODUCTION

The Irish potato is a native of the Andean highlands in South America. Its first introduction into the Philippines is not definitely known, but the so-called "Native" varieties that are being grown in the Mountain Province, Cebu, and other regions, must certainly have been introduced by the Spaniards. These strains are generally regarded as Spanish potatoes; they have small tubers.

During the American régime, subsequent introductions of potatoes were made, both by the Government and by private gardeners, particularly the Japanese. One of the most remarkable attempts of the Government to induce the Mountain people to grow potatoes was made in 1918, when hundreds of crates of potatoes from America were distributed free in the Mountain Province. These introduction failed, however, perhaps because of a lack of knowledge of the proper cultural requirements of the crop, and because of the non-adaptability of these potato varieties to conditions obtaining in the region.

Varieties grown in the Mountain Province.—The varieties that have been found adaptable to the Mountain Province are early maturing ones. They come to maturity about three months after planting. The most important of these are: Japanese White, "Native" or Spanish potatoes, Japanese Red, and a few early American varieties.

Japanese White potato.—This variety was introduced from Japan by Japanese gardeners. It matures in three months and is fairly productive with good-sized tubers. It is known to have produced from 14 to 16 crates of good tubers in Trinidad Valley, Mountain Province, for every crate [3] of seed planted during good years. The tuber is spherical to oblong in shape with rather shallow eyes (Plate 3*a*). As the name indicates, the skin is white; the quality is excellent. It is very popular in the Baguio market.

"Native" or Spanish potato.—This is believed to be one of the first grown in the Mountain Province, hence its being called "native." It is considered as Spanish variety, nevertheless. It also matures in about three months. The tuber is small, ranging in size from 2.5 to 4.0 centimeters in diameter (Plate 3,*b*) generally oblong in shape, deep-eyed, and of a white skin. It has excellent eating qualities.

Lanao potato.—This is an acclimatized American variety grown in Bayang District near Lake Lanao. This potato is large with shallow eyes, mealy and of excellent quality. Due to excessive rainfall, lack of preventive measures against diseases, and the ignorance of the Maranao growers as to its cultural requirements, this crop has not made much headway.

Japanese Red.—This potato, also introduced from Japan, matures in three months or more and is more productive than the

[3] One crate of potato weighs about 44 kilos and can plant about 1/30 ha. (330 sq. m.).

Japanese White. The tuber is spherical, but bigger than the Japanese White; the skin is reddish brown. The tuber is borne on a long peduncle, especially in friable soil. Its eating quality is inferior to Japanese White, and its keeping quality is poor.

May Queen.—Rodrigo and Urbanes (1934) in their progress report on the introduction and acclimatization work at the Lipa Coffee-Citrus Station, Lipa, Batangas, state that May Queen, a new variety of Irish potato from England, is very promising. It is hardy and productive and comparable to the Japanese White in yield. The tuber of this variety is oblong in shape, but thicker on one side; the eyes shallow, the skin white and the appearance very neat (Plate 4, *1*). Its eating and keeping qualities are very good. Other varieties reported to be promising under Lipa conditions are Glasgow Favourite, Burbank (Plate 4, 2), and Oregon.

PROPAGATION

The Irish potato is commercially propagated by the use of its tuber as seed. In temperate countries, the seed proper is used for the production of new varieties or strains. In the Philippines, the potato has not yet been known to produce any seed.

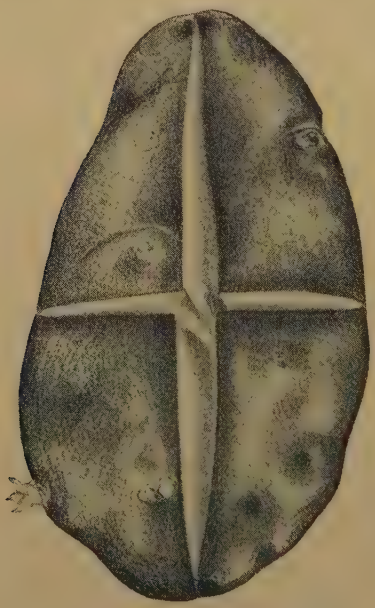

FIG. 1. Showing the proper method of cutting a seed tuber. The cut is made horizontally or vertically irrespective of the location of the "eye".

Seed potato.—In the growing of potatoes in the Islands, the question of seed is one of the limiting factors. So far as is known the seed does not store well for the next planting season under local conditions. The tubers in storage sprout and finally shrivel long before planting time. Thus they are devitalized and inferior to imported seed. The seed, therefore, is imported from other countries, mostly Japan and China.

In places where the "native" potato is raised, the practice is to have different sets of planting during the year in order to keep up a continuous supply of fresh tubers. During the rainy season, however, limited plantings are made on hillsides where the soil is generally well drained. This

is the practice in Nueva Vizcaya, Mountain Province, and in Cebu.

The seed for planting should be ordered from reliable houses a few months before planting. This procedure insures a good supply of fresh and sound tubers. It should be borne in mind that without good seed it is impossible to produce heavy yields. Buying seed from the market as the need arises is not safe and in the long run may prove to be far more expensive.

The variety to be selected should be one that is adapted to the region and at the same time commands a good price. It is important that the seed be pure and true to name, the tubers sound and free from any sign of disease infection, and with sprouts just starting to develop. Medium-sized tubers are preferable. Shriveled ones and those with long sprouts should never be used for planting as they are inferior in germinating as well as in yielding power. The Japanese White and the May Queen varieties are recommended for general culture in the Philippines. The Japanese White is cheaper and easier to secure than the May Queen, since it is being imported into the Islands in big quantities. Other varieties that can be used are Japanese Red, Chinese Red, Oregon, etc. If the seed tubers are received quite early they should be spread in a cool dry cellar until planting time so as to minimize sprouting.

Seed treatment.—The greater bulk of the potato seed used in the Islands is imported. It would be a wise policy to treat it with disinfectants before planting so as to prevent the introduction of seed-borne diseases like scab, root rot, etc. Of course, seed treatment does not cure all seed ills; it serves only as a safeguard against surface-borne diseases. The virus diseases are in no way affected by any kind of seed treatment.

The common materials in use as seed potato disinfectants are corrosive sublimate (mercuric chloride), acid mercury dip, and formaldehyde. Following are the standard solutions and methods or treatment:

Corrosive sublimate.—Dissolve 4 ounces (113.4 grams) of corrosive sublimate in 4 gallons (15.14 liters) of hot water; then add enough water to bring the total amount to 30 gallons (113.50 liters). Potato seed should be soaked in the solution from 1 to $1\frac{1}{2}$ hours, after which it should be dried before cutting for planting. Wooden vessels should be used in treating seed with this solution as it attacks metals. The solution may be used three times without losing its strength. *Corrosive sublimate is a dead-*

ly poison when taken internally and every precaution should be taken in its use.

Acid mercury dip.—Dissolve 18 grams of mercuric chloride in 100 cubic centimeters of commercial hydrochloric acid. Then add enough water to make the total solution 10 liters. Potato seed tuber should be soaked in the solution from 5 to 20 minutes, depending upon the condition of the seed, after which it should be dried before cutting for planting. As in the case of the corrosive sublimate, wooden vessels should be used and every precaution taken to avoid poisoning.

Formaldehyde (formalin).—The potato seed should be soaked in formalin (40 per cent formaldehyde) solution, 1 pint (0.473 liter) to 30 gallons (113.56 liters) of water, from 1 to 2 hours. The seed should then be dried before it is cut for planting. The same solution may be used about 10 times with good effect, but must not be allowed to stand for any length of time before use.

Cutting the seed.—The tubers should be cut more or less in uniform sizes with at least two eyes in each cutting (see Fig. 1). The cut should be made above the eyes rather than below them. It should be borne in mind that under unfavorable conditions a good-sized cut has a greater chance to germinate and to produce a healthy plant than a small-sized one. Nothing is to be gained by making the cuts too small with the idea of economy on the seed tubers. Hutcheson and Wolfe (1917) found that 1-ounce (28.3 grams) cuts are best when the seed tuber is vigorous. Small entire tubers may be used, if taken from healthy and productive plants.

Cutting the potato in advance so as to dry the cut surface has no particular advantage. On the other hand, when cut potatoes are kept long in piles without proper suberization, there is danger of spoilage due to over-heating. A good practice of gardeners in the Mountain Province is to dust the wound with an absorbent material such as wood ash before planting. The idea is to dry the wound and possibly to prevent rotting as much as possible.

PREPARATION OF THE SOIL

Like any other root crop, the potato requires a thorough preparation of the soil. The potato, as grown in the Philippines, matures in three months. It is evident, therefore, that the soil should be worked in such a manner as to give the best medium for growth during the short growing period of the crop. Such

a preparation involves deep plowing and thorough pulverization of the soil prior to planting.

The field for potato should be broken soon after the heaviest rain is over, to give enough time for the green manure crop or weeds to decay and decompose before the seed is set in. In this connection, it should be borne in mind that the cleanliness of the field is a factor of prime importance in potato culture. In general, the preparation of the soil is similar to that for sweet potato and peanut.

In Trinidad Valley, Mountain Province, the gardeners grow potato in "raised beds." This is because potato is rotated with vegetable crops like cabbage, pechay, etc., which are being grown in "raised beds." Consequently, no animal-drawn implement is used in connection with the culture of potato. This method, however, is limited to small-scale farming; so it is not recommended for planting on a large scale.

THE USE OF MANURE AND COMMERCIAL FERTILIZER

Stable and green manures.—Stable and green manures are no doubt beneficial to potato. They insure a generous supply of organic matter in the soil, besides adding plant food elements. The use of stable manures, especially fresh ones, should, nevertheless, be regulated as, according to Noll (1916), it tends to make the potato scabby. Manures should be applied to the crop preceding the potato. When green manure crop is plowed under, this should be done early enough to give ample time for decay and decomposition. Cowpea, tapilan, and soybean make excellent green manure crops; they are efficient in smothering weeds, thus providing clean culture. Besides, they give a heavy tonnage of vegetable matter when planted during the early part of the rainy season, provided the soil is well drained. In the Mountain Province the gardeners use a great deal of humus from decomposed vegetable refuse and ash from pine leaves and grasses for the potato.

Commercial fertilizer.—The potato responds well to the heavy application of commercial fertilizers. The amount to be applied and the composition of the fertilizer vary in different places, depending upon the type and fertility of the soil, the climate, and the crop sequence in vogue.

A two-year potato fertilizer experiment conducted by the writer (1933) at the Baguio Semi-temperate Fruit Station showed that the fertilized plots gave increased production, and the in-

crease in yield was more or less proportional to the amount of fertilizers applied. The fertilizer, which contained 9 per cent nitrogen, 12 per cent phosphoric acid, and 9 per cent potash (9–12–9), was applied at the rates of 200, 450, and 700 kilos per hectare. The increases in yield over the unfertilized plots were 29, 74, and 89 per cent, respectively. Table 1 presents the result of this fertilizer experiment as summarized.

TABLE 1.—*Showing the effect of different amounts of commercial fertilizer (9–12–9) on potato production, 1930–1932.*

Rate of application per hectare.	Marketable tubers only.			
	1930–1931 test.	1931–1932 test.	Average.	
				Relative.
Kilos.	*Kilos.*	*Kilos.*	*Kilos.*	*Per cent.*
Check	2,136	4,240	3,188	100
300	3,120	6,280	4,700	136
450	4,208	7,520	5,864	174
700	4,560	8,200	6,380	189

Taking net income as the criterion, fertilizers of high concentration (10–16–14) used less in amount 181.44 kilos per hectare (400 pounds per acre) have been found to be more beneficial than less concentrated ones (5–8–7), even when the latter have been applied in quantities twice as much as the former (1930). Generally speaking, as results of experiments have shown, phosphorus is the most important element in the fertilizer for potato. It not only increases the yield but it also hastens maturity, and to some extent makes the plant more resistant to fungus diseases. Acid phosphate is a good source of phosphorus for potato. Wood ash and pine leaves ash in the Mountain Province, which can be procured at comparatively low prices, make good sources of potash.

How to apply fertilizers.—Fertilizers can be more advantageously applied in the furrow before planting. When applied in the rows, the fertilizer should be mixed thoroughly with the soil to prevent any possible injury to the germinating plants. Broadcasting the fertilizer evenly over the field just before the last plowing is not economical; a high percentage of the fertilizer will not be within the reach of the plants.

PLANTING AND SPACING

Time of planting.—With regards to the best time for planting, only general suggestions can be given, as this depends upon the prevailing conditions in a given locality. The best time can only be ascertained after extended study for a number of years. It is safe, however, to plant when the rainy days are practically over. In Baguio and in Trinidad Valley, the season for planting potato is from November to February. A two-year test previously reported by the writer (1933) at the Baguio Semi-temperate Fruit Station showed that the plots planted on December 15 and January 15 gave the best average yields. Table 2 gives a summary of this two-year test. The trial, while it was not conducted through a sufficient number of years to make the result conclusive, virtually indicated that there is a certain time most suitable for the heaviest production of potato.

TABLE 2.—*Showing the effect of date of planting on the yield of marketable tubers per hectare.*

Date of planting.	Yield of marketable tubers per hectare.			
	1930–1931 [a]		1931–1932	
	Kilos.	Relative.	Kilos.	Relative.
		Per cent.		*Per cent.*
November 2			3,640	100
November 15	736	100	4,640	128
December 15	3,000	408	7,280	200
January 15	2,440	345	7,560	205
February 15	1,440	196	6,280	173

[a] This crop was neither fertilized nor sprayed with Bordeaux mixture.

Spacing.—Inasmuch as the Irish potato has neither a wide spreading root system, nor a tall and spreading foliage, it can be planted rather close together. In field culture the tubers are planted in rows of about 75 to 80 centimeters apart. Furrows are made and the seed is dropped and covered therein about 25 to 30 centimeters apart; one cut is planted in a hill. This distancing of the furrows or rows allows the use of animal-drawn cultivators. In garden cultures the tubers are planted in beds and set about 30 centimeters apart each way.

Depth of planting.—The common practice in Trinidad Valley, Mountain Province, is to make holes with a digging hoe wherein

the cuts are set. These holes are about 4 to 7 centimeters deep. This method is practicable in small gardens. In field culture, furrows should be opened with a plow to a depth of about 7 to 10 centimeters and the cuts covered with 4 to 6 centimeters of moist soil. The depth of planting, of course, may be varied according to the texture and moisture content of the soil.

CARE OF THE CROP

The care of the crop after planting up to harvest time consist chiefly of cultivation and weeding, irrigation, and control of diseases and pests.

Cultivation and weeding.—The plants do not come up until about two or three weeks after planting. During this period weeds sprout, and will be hard to eradicate if cultivation is delayed until the plants are well up. A good practice is to harrow the field before the plants come up as weeds begin to show up; this method of cultivation should be repeated as necessity demands. Care, however, should be taken always to pass the animal between the rows so as not to trample on any of the germinating plants. The importance of these early cultivations cannot be over-emphasized as they kill the weeds between the hills which will certainly be hard to eradicate with an ordinary cultivator at a later date. When the plants are a few centimeters high, they should be cultivated with ordinary cultivators often enough to keep down weeds and to keep the soil in good tilth. During the last cultivation, the soil should be thrown towards the plants thus putting them in ridges. The native moldboard plow is good for ridging. All cultivation should cease when tubers are about the size of finger tips.

Thinning.—However sound the seed potato may be, the number of shoots that may arise from a single cut cannot be determined in advance by the number of "eyes" in the cut. Actual counts at the Baguio Semi-temperate Fruit Station and at the Lipa Coffee-Citrus Station showed that the number of shoots coming up from a single cut having two or more "eyes" varied from one to nine. Observations made in Trinidad Valley, Mountain Province, showed that when four or more shoots develop from a cut, the size of the tubers produced was greatly affected, and the percentage of culls was comparatively high. The plants, therefore, should be thinned to two or three per hill when they are about 10 to 13 centimeters high. This treatment has the tendency to reduce the number of tubers produced, but

at the same time, it is conducive to the production of bigger and more uniform ones. In thinning, the most vigorous and sturdy shoots should be left, and care should be taken not to disturb the root system of the plant.

Irrigation.—Where irrigation water is available, it is advisable to irrigate the field when it becomes dry. This will insure a better crop. Irrigation should take place before the last cultivation, and should not be allowed to soak the field for any length of time.

Control of pests and diseases.—As the plants begin to come up there should be continuous vigilance for the appearance of pests and diseases, particularly the potato blights. As soon as signs of potato blight infection are observed, the plants should be thoroughly and constantly sprayed with Bordeaux mixture (4–4–50 or 5–5–50). The plants may be sprayed as often as three times during the growing period, at two-week intervals or after a strong rain, depending upon the severity and persistance of the diseases. The success of any control measures used revolves on the promptness and thoroughness in executing the work.

HARVESTING

The drying of the vine or its turning yellow are signs of maturity. Most varieties grown in the Philippines mature in three months. Another index of maturity is when the tuber does not skin readily upon rubbing the finger against it. Of course, there are times when the crop is harvested even if not matured. This is done when the crop is badly infected with potato rot so as to save a great portion of the tubers. Also, when there is a big demand for potato and the price is high, the crop may be harvested immature just to catch the high price.

If the days are rainless, there is no danger in delaying the harvest, provided the plants are not attacked by potato rot. Under ordinary conditions, the crop should be harvested as it is matured. A good time to harvest is in the morning. It is advisable to leave the harvest in narrow windrows in the field for two days or so in order to wilt the skin and thus prevent unnecessary bruising in hauling and handling. A spading fork and sometimes a spade are excellent tools for digging. The plow is not recommended, as in the case of the sweet potato, due to the fact that the tuber separates easily from the peduncle, resulting in a loss of many tubers left covered in the ground.

As the tubers are collected from the field, the culls should at once be separated from the marketable ones. This method markedly reduces the cost of hauling and handling. Of course, if the market warrants it, further sorting may be done later. The marketable tubers should be directly put into wooden crates, and hauled as such. Putting them into burlap sacks should be avoided as much as possible so as to prevent too much bruising which naturally decreases the market value of the tubers and lowers their keeping quality. The crates should be of convenient size and weight to be easily carried by a person and piled one on top the other in the storage room. The corners of the crates should be rounded in order to insure a free circulation of an abundant supply of fresh air.

Another convenient container for hauling is a bamboo basket or crate, which are cheap, but have the disadvantage that they cannot be piled one on top the other as they are not rigid enough to withstand heavy pressure.

How long the potato will keep in good condition in the Philippines is not yet definitely known. Under Baguio and Lipa conditions, the tuber has been found to be in good condition six months after harvesting. If the price is reasonable, it would be safer to dispose of the product soon after harvest. However, when one is forced to store his crop because of low prices, he should do so in cool and dry cellars. Comparatively dry air is an important factor in storing potato. Potatoes for culinary purposes should not be spread in an open room while in storage; they should be put in crates or sacks. Stuart (1930) reports that when exposed to light potato turn greenish due to the formation of a certain substance called solanine. This substance has been found to be injurious to health. All tubers with any visible sign of potato rot should be excluded from the crates.

DISEASES AND PESTS

Diseases.—There are at least four known important fungus diseases a potato grower in the Philippines may have to combat. A thorough knowledge of their symptoms and methods of control is essential in order to be able to minimize their effects, if not to control them entirely.

Early and late blights.—These are the worst diseases of potato in the Mountain Province, and often they prevent the full maturity of a crop. The diseases seem to be more prevalent on potatoes planted in October, November, and December, when the air is still very humid and the temperature rather low. Blights have also been observed on potatoes in Lipa, Batangas, but were not so severe there.

The early blight is caused by a fungus known as *Altenaria solani* (Ell and Mart) L. R. Jones and A. J. Grout. It attacks only the leaves, forming brown spots. These spots, more or less circular, are distinctly marked with concentric rings, giving them a target-like appearance. In severe cases the spots become large and unite with one another, sometimes covering the entire leaf. While the stem is not affected, it soon dies because of defoliation.

The late blight is also a fungus disease, and is caused by *Phytopthora infestans* (Mont.) De By. It generally appears in the latter part of the growing stage, and attacks the leaves, stems, and even the tubers. The disease takes form on the leaves as dark, water-soaked areas. The spots generally begin to form at the tip or edge of the leaf and spread indefinitely, unlike the early blight. The stem may become affected in like manner. The tuber when affected produce discolored, water-soaked areas.

Control measures.—Both the early and late blights can be controlled by a systematic use of Bordeaux mixture spray of the 4–4–50 or 5–5–50 formula. The former mixture is made by using 4 pounds (1.814 kilos) of copper sulphate, 4 pounds of unslacked stone lime, and 189.25 liters of water, while the latter is made by using 5 pounds (2.27 kilos) of copper sulphate 5 pounds of stone lime and the same amount of water as in the former.

Usually the first spraying should be done about two weeks after germination. The vines should be carefully examined throughout the growing season and sprayed at once whenever signs of blight appear. If the sprays are promptly and properly administered, especially the first ones, the blight will be greatly reduced if not entirely checked. Success in spraying also depends largely upon clean cultures. All badly diseased plants should be collected and burnt so as to remove sources of rapid infection.

Potato scab.—This is another fungus disease of potato caused by *Actinomyces scabies* (Thax.) Guer. It attacks only the tubers. The plant may appear perfectly healthy, but the tubers may be cankered. Early infection appears as "small, brownish

spots which later enlarge into rough, corky, brownish patches." The whole tuber may be covered in advanced stages.

Control measures.—The origin of infection is either the soil, or the seed, or both. If the field has been badly infected, it is advisable to practice a systematic crop rotation. The use of inoculated flowers of sulphur at the rate 224.5 to 336.8 kilos per hectare may help control the scab. The sulphur should be broadcast and mixed thoroughly with the soil. Lime should be used sparingly, since alkaline soils favor the development of the disease.

All seeds, especially the imported ones, should undergo presoaking in such toxicants as corrosive sublimate, acid mercury dip, or formaldehyde before planting as has been stated elsewhere in this article.

Tuber rot.—This potato disease is caused by some species of *Fusarium,* causing rotting of the base of the stem and, in advanced cases, of the tubers. Rotten tubers are reduced into a sticky mass and emit a foul odor. The casual organism is carried in the soil, but new infection is mostly a result of the use of infected seed. It is, therefore, advisable to treat seed for planting, as already stated, even if it appears free from infection. If the soil has been heavily infected with the disease, rotation of crops should be resorted to. The use of soybean and other suitable legumes should prove beneficial.

PESTS

Cut worm.—The larva of this insect cuts the stem of the plant and sometimes the tubers. It attacks also cabbage, tomato, and many other garden crops. It feeds at night and hides in the soil or among dry grasses during the day.

The cut worm menace can be controlled by the use of poison. Add 1½ pounds (.068 kilos) of arsenate of lead paste to each 50 gallons (189.3 liters) of Bordeaux spray. Hand picking is also practical and effective. When signs of cutting appear, the worms can usually be found around the bases of the plants, as it is in the soil there that they seek refuge during the day.

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ILLUSTRATIONS

PLATE 1

A view of a semi-commercial potato field at the Baguio Semitemperate Fruit Experiment Station, Baguio, Mountain Province (Plants about four weeks old).

PLATE 2

1. A view of the acclimatization test on Irish potato at the Lipa Coffee-Ctrus Station, Lipa, Batangas, 1933–1934. This portion represents the United States, Japanese, and Chinese varieties.
2. Another view of the 1933–1934 acclimatization test on Irish potatoes at the Lipa Coffee-Citrus Station, Lipa, Batangas. This portion represents the English varieties; the row marked (X) was the May Queen variety.

PLATE 3

Typical tubers of (*a*) Japanese White, and (*b*) "Native" or Spanish potato. Note the relative sizes of the tubers. (About three-fourths natural size.)

PLATE 4

1. Typical tubers of May Queen variety, a new introduction from England. Note the characteristic shape of the tubers and the shallow "eye." This variety is productive and hardy.
2. Typical tubers of Burbank potato. Note the shape and the characteristic markings of the tubers.

TEXT FIGURE

FIG. 1. Showing the proper method of cutting a seed tuber. The cut is made horizontally or vertically irrespective of the location of the "eye."

PLATE 1.

1

2

PLATE 2.

a

b

PLATE 3

1

2

PLATE 4.

CAIÑGIN RICE

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THREE PLATES

Caiñgin is the primitive way of planting early rice in the Philippines. This method has never been followed on a large scale. Probably no one has yet investigated the cost of producing one hectare of rice by this method. However, various estimates of producing one hectare-crops of lowland rice, based on the combined factors affecting the cost, such as the rate of wages, the price of commodities, irrigation fees, etc. were made. In this paper the writer will discuss the method of culture and production of caiñgin rice.

Procedure.—The investigation was performed during the rice season of 1930. Fourteen tenants were permitted to choose sites for their individual caiñgin within the Lamao Experiment Station ground at Limay, Bataan. The time covered by this work was from January to June, the latter month being the last time to plant caiñgin rice profitably. To secure as much accurate data as possible it was necessary for the writer to be on every caiñgin from the time of preliminary clearing to planting time, for computations and counting the number of people actually engaged, the length of time consumed for a particular job, the cleared area together with the cash expenses for meals and other sundries. The figures thus obtained were taken as a basis for calculating the labor and expenses per hectare presented in the following tables. Under agreement the Government obtained 10 per cent of the net yield of rice for the use of the land, that is, after deducting 20 per cent of the gross yield for harvesters. The caiñgin were prepared by coöperative system among the tenants themselves to eliminate expenditures for labor. The cash expenditures incurred in the undertaking were for food and sundries, shown in every table. The value of labor is taken as man-days. All data pertaining to specific jobs and the corre-

sponding number of laborers are given in Tables 2 to 7. A brief description of each stage of a caiñgin is given.

The caiñgin.—Caiñgin in general consists in clearing virgin or second growth forest land, and planting it to early maturing rice, technically known as *upland.* The maturing period of such rice is short, ranging from 100 to 145 days. As a rule these varieties are low yielders, compared with lowland varieties. It is believed, however, that there are certain varieties that can be made to produce higher yield. The success of this rice depends upon the variety, the time of planting, and the amount of rainfall during the vegetative period up to dough stage. In provinces under Type I climate, the time limit for planting upland rice is from May 15 up to June 25. Beyond this limit there is the danger of losing the crop by drought at the bunting stage. Three hundred sixty eight mm. (14.48 inches) of rain in June and an average of 569.1 mm. (22.17 inches) monthly during the months of July up to September will mature a normal crop. Provinces having higher altitude will mature a normal crop with less rainfall. Periodic drought is harmful. Continuous rain after the milky stage prolongs the maturing period by several days.

In Batangas province and upland towns of Cavite where there is little lowland rice, shortage of this cereal is common. To make up for this deficiency spaces between young coconut trees, bananas, coffee, and other permanent crops, are planted to upland rice as a *catch-crop.* Caiñgin land is used generally for two years, rarely three; a longer time is contrary to the principle of *crop rotation.* The fertility of the soil after this length of time decreases appreciably, primarily due to soil erosion, while the caiñgin becomes very weedy. If such land is not intended for permanent planting with other crops, it is relinquished to the growth of smaller timbers or second growth forest for some years before it is reopened for another caiñgin. This method is called *rejuvenation.* This type of caiñgin is found in the upland towns of Cavite where there is more land than the people can work at a time. Caiñgin from a virgin forest, produces more than that of a second growth.

There are a few principles to be observed in caiñgin planting in order to save time, labor, and unnecessary expense. In

Table 1 are found the location, the owners, and the area of the caiñgin under consideration.

Preliminary clearing, first step (*hawan*).—Preliminary clearing is done by man only. It consists first of clearing the shrubs, vines, and other underbrush, leaving the big timbers untouched. The shrubs, vines, and underbrush are cut further into shorter pieces and pressed down to the ground together with the leaves and allowed to dry. Meanwhile, the party of laborers, all owners of caiñgin, moves the other caiñgin belonging to another member of the group for similar jobs. The owner furnishes meals and other supplies for the whole party. In Table 2 is shown the average number of man-days and expenses necessary in the preliminary clearing of one hectare-caiñgin. On the average, 24.3 man-days and ₱12.32 for meals and sundries are required for the preliminary clearing of one hectare-caiñgin.

Lopping, second step (*hapay*).—Felling or lopping of timbers comes next in the order. The idea of preliminary clearing is to give the timbers free fall when chopped down. Judgment should be exercised carefully in chopping for timbers cut haphazardly often remain leaning against each other. As in preliminary clearing, all timbers properly lopped down are further cut into convenient lengths as well as the branches. About April all caiñgin should be cleared and lopped ready for burning. In Bataan burning caiñgin is usually done on Good Friday, as it is considered the hottest part of the year in the Philippines. An average of 15.9 man-days and ₱8.15 for meals is required for lopping one hectare-caiñgin (Table 3).

Collecting, third step (*dulok*), *and preliminary weeding, fourth step* (*gusad*).—Collecting and preliminary weeding are done simultaneously. All partially charred woods left after burning are collected, gathered and piled up above and around the stumps of trees and burned further. At this time the caiñgin is almost cleared and free of trash. If the land is intended for permanent planting with other crops the stumps are either dug out or burned continuously down to the roots so as to remove the stumps that hinder plowing. The process is slow and expensive. Shortly after burning, weed seeds start germinating and continue to multiply rapidly until the entire place is covered. At this time the preliminary weeding is started. This job is entrusted

to women and children. A good caiñgin is one in which the weed seeds are allowed to sprout and are pulled up several times before planting rice. The weeding is done with the use of a bolo called Tiyad (Plate 1, fig. a). There is advantage in doing this first, as it avoids repeated and subsequent weeding, which is harmful. A clean caiñgin at the start will always produce vigorous plants leading to a good crop. A weedy rice field needs repeated weeding to save the crop, but the plant suffers from being trampled on. The average number of man-days required to collect charred wood and the expenses per hectare are 20.3 and ₱7.36, respectively, while for preliminary weeding, 19.3 man-days with the cash expenses of ₱5.77. (See Tables 4 and 5.)

Planting, fifth step (*bakal*).—In Lamao and its neighborhood two kinds of implements are used for planting caiñgin rice, the *baliway* and the *balawang*. The baliway is made from one internode of native boho (*Schizostachym lumampao,* Blanco) one end of which is provided with a blunt blade of hard wood, usually narra or molave. Boho is preferable for its lightness. The blade is so blunt that it can hardly make holes on baked surface. Its other end is attached to a handle, made from a soft and light wood. Around the two ends of the boho are series of rattan rings to prevent breakage. (Plate 1, letters d and e). Upland rice is planted directly on the field. Three to eight seeds are dropped in each hole. The holes are 10 to 15 centimeters apart. In planting, every man standing in line-up fashion transfers his baliway from one hand to another and vice versa thrush it to the ground as he steps backard covering a space wide enough for the reach of the tool. While the woman with the seed container, usually a coconut shell, in one hand steps forward following her man, drops the seeds into the holes and covers them with dirt by means of her feet. As in lowland rice planting, musicians are sometimes hired to play and keep up the time (Plate 2). Unconscious or careless planters drop more than necessary, wasting the seed and giving the trouble of subsequent thinning during the weeding.

The *balawang* is made from the smaller end of native spiny bamboo (*Bambusa spinosa, Blanco*), its tapering end is provided with a sharpened iron blade. The holes are 10 to 15 centimeters apart but deeper than those of *baliway*. The larger end

of the *balawang* or butt is split into smaller sticks three internodes long. These pins produce a hizzing sound that keeps the time for the planters. The *balawang* has a longer radius. Two women step forward, following one man (Plate 3). The movement of planters in the *balawang* method is similar to that in the *baliway*. The latter makes no holes on baked surface, thus the seed is exposed to the danger of being picked up by birds, or washed away by the rain, and the germ may die, due to alternate exposure to the heat of the day and the coolness of the night. This very often happens when planting is done immediately after the first strong rain in May or June, followed by long sunny and sultry days characteristic of regions having distinct wet and dry seasons. This is the transition period. With the use of *balawang*, an average of 21 man-days were required to plant one hectare-caiñgin as against 24.6 man-days with baliway, giving to the former an advantage of 4.9 man-days, plus three man-days for musicians not considered in Table 7.

Seeding.—A good rate of seeding in caiñgin is 25 gantas per hectare when the percentage germination is 90 or above and 30 gantas when the germination is below this figure. Seed with percentage germination below 80 should not be used if possible. Plants grown of such poor seed are weak and sickly. Very thick planting both in lowland and upland produces weak and spindling plants with few tillers, and unless remedied in the early stage will produce a poor crop.

Weeding, sixth step (*gamas*).—Caiñgin rice is weeded when it is from 30 to 45 days old or when the plants are about 15 to 25 centimeters tall. Beyond this age the plant suffers and development is checked. The right time to weed is on cloudy days with light showers when the soil is moist and friable. The thinning, cultivation, and replanting are done together at this time with the use of *Tiyad* (Plate 1, a). The average number of people required to weed a hectare-caiñgin was sixteen, the range being 12 to 20, depending upon the intensity of the growth of the weeds.

Harvesting, seventh step (*ani*).—Harvesting is performed by men, women, and children. One, two, or three heads are clipped off at a time with the aid of small scythe attached to a cylindrical piece of wood called *Pang-ani* or *Yatab* (Plate 1, b). This

method of harvesting is slow and tedious but very little grain is lost. The heads are clipped 4 to 6 inches below the base of the first spikelet, just long enough to enable one to grasp them. Handful of these heads are placed in a basket or a cloth bag tied around the waist of the harvester. A harvester usually gets an average of six gantas of grain for a day's toil. Harvesting very often is done only in the morning and the rest of the day is devoted to threshing and cleaning the grain. Harvesters get only 10 per cent of the crop in heads, but when they are required to thresh, clean, and dry the grain, they get 20 per cent of the grain. Only those who helped in the planting are given the privilege to harvest.

Summary.—Nine varieties of upland rice were planted in the caiñgin under consideration, namely the Kinastila, Pinaguimbing, Guinolong, Dinolaro, Sanglay, Binangiao, Kinalabao, Binicol, and Binankero. The variety Kinastila had the best stand. The total area of caiñgin was 18.9 hectares with corresponding gross yield of 451.9 cavans or an average of 23.4 ± 1.05 cavans per hectare with standard deviation of 5.65 ± 0.75 and a coefficient of variability of 24.13 ± 3.34 per cent. From the gross yield 90.38 cavans equivalent to 20 per cent was deducted for the harvesters. Another 36.15 cavans equivalent to 10 per cent of the remaining 361.52 was again deducted for the use of the land. In other words, the tenants obtained an average of 17.21 cavans only per hectare of caiñgin rice for which they spent ₱56.01 in cash besides the labor of 69.2 man-days and 47 woman-days. Using the data in Table 8, and allowing ₱1 and ₱0.70 wages per day for man and woman labor, respectively, the cost of producing one hectare of caiñgin rice in Lamao, Bataan, at the time of investigation was ₱158.11 or ₱9.18 net per cavan.

TABLE 1.—*Number, area and owners of caiñgin under these investigations.*

Caiñgin number and name of owner.	Area.	Location.	Topography.	Number of years under caingin.	General condition of land prior to cleaning.
	Sq. m.				
1. V. Villaluz	11,158	Ayam, Limay, Bataan.	Undulating	First year	Second growth forest land.
2. B. Leyson	5,697	do	do	do	Heavily timbered land.
3. A. Baluyot	13,071	do	Rolling	do	Do.
4. C. Baluyot	19,597	Lamao Experimental Station, Bataan, North Side.	do	do	Second growth forest land.
5. L. Marcelo	8,501	Lamao Experimental Station, Bataan, South Side.	Hilly and sloping.	do	Heavily timbered land.
6. P. Layola	18,384	do	do	do	Second growth forest. Under caiñgin previously.
7. J. Bejasa	16,095	do	do	do	Do.
8. M. Callena	18,164	Lamao Experimental Station, Bataan, North Side.	do	do	Do.
9. A. Aritmetica	13,956	do	Undulating	Second year	Stumps, vines, and young timbers.
10. A. Aritmetica	12,721	do	do	First year	Second growth forest.
11. G. Balmaceda	14,222	do	Rolling gently.	do	Second growth forest. Under caiñgin before.
12. S. Magnaye	5,578	do	do	do	Second growth forest.
13. A. Cruz	25,311	do	Rolling abruptly.	do	Virgin forest.
14. A. Marquez	6,848	do	do	do	Do.

TABLE 2.—*Preliminary cleaning* (*Hawan, first stage*).

Caiñgin No.	Actual.		Computed per hectare.	
	Man-days.	Expenses.	Man-days.	Expenses.
1	38	₱22.75	34.0	₱20.33
2	21	10.92	37.0	19.24
3	30	15.00	22.9	11.45
4	77	45.60	39.3	23.26
5	13	4.50	15.3	5.29
6	36	27.50	19.5	14.89
7	21	15.65	13.0	9.68
8	35	17.50	19.2	8.75
9	50	15.00	24.4	4.50
10	20	8.00	15.8	6.32
11	31	15.50	21.9	10.95
12	10	4.50	17.9	8.06
13	64	25.60	25.3	10.12
14	15	5.20	21.9	7.58
Average			24.3	12.32

TABLE 3.—*Felling and lopping of timbers* (*Hapay, second stage*).

Caiñgin No.	Actual.		Estimated per hectare.	
	Man-days.	Expenses.	Man-days.	Expenses.
1	27	₱13.50	24.0	₱12.00
2	18	8.10	32.0	13.31
3	20	14.50	15.3	11.02
4	52	31.20	26.5	15.90
5	12	5.60	14.1	6.57
6	25	9.75	13.6	5.30
7	14	9.00	8.7	5.52
8	26	13.00	14.3	6.50
9				(a)
10	15	6.00	11.8	4.72
11	19	9.50	13.3	6.65
12	5	2.40	8.9	4.27
13	29	13.05	11.4	5.13
14	9	3.10	13.1	4.50
Average			15.9	8.15

[a] Done by contract.

TABLE 4.—*Cutting, collecting, and piling unburned logs (Dulok, third stage).*

Caiñgin No.	Actual.		Computed per hectare.	
	Man-days.	Expenses.	Man-days.	Expenses.
1	32	₱12.80	28.6	₱11.44
2	17	4.65	29.8	8.13
3	34	10.50	26.0	8.00
4	72	21.60	36.9	11.07
5	17	4.50	20.0	5.30
6	28	8.40	15.2	4.56
7	26	9.90	16.1	6.12
8	27	14.00	14.8	7.66
9				[a]
10	15	7.80	11.7	6.08
11	25	10.00	17.5	7.00
12	7	2.40	12.5	4.28
13	32	15.20	12.6	5.98
14	15	3.60	21.9	2.25
Average			20.3	7.36

[a] Done by contract.

TABLE 5.—*Preliminary weeding prior to planting (Gusad, fourth stage).*

Caiñgin No.	Actual.		Computed per hectare.	
	Woman-days.	Expenses.	Woman-days.	Expenses.
1	35	₱8.40	31.3	₱7.51
2	14	3.00	24.6	5.27
3	22	6.42	16.8	4.89
4	40	12.00	20.4	6.12
5	19	4.75	22.3	5.58
6	35	14.00	19.0	7.60
7	33	8.25	20.5	5.13
8	28	10.50	15.4	5.73
9				[a]
10	25	5.00	19.6	3.92
11	20	8.75	14.0	6.12
12	8	3.45	14.3	6.14
13	38	10.30	15.0	4.06
14	12	3.65	17.5	5.32
Average			19.3	5.77

[a] Done by contract.

TABLE 6.—*Planting, Balawang, (Bakal, fifth stage).*

Caingin No.	Actual.			Computed per hectare.		
	Man-days.	Woman-days.	Expenses.	Man-days.	Woman-days.	Expenses.
1	10	11	₱25.00	8.9	9.8	₱22.40
2						
3	5	10	18.40	13.7	27.4	50.39
4	7	10	17.20	5.5	7.8	13.49
5	5	10	8.00	5.8	11.6	9.41
6	10	21	15.10	8.2	17.3	12.46
7						
8	8	18	18.10	5.4	12.3	12.30
9						
10						
11						
12	7	14	5.60	16.8	33.5	13.42
13						
14	4	8	4.40	5.8	11.6	6.42
Average				7.4	13.6	14.86

[a] This caingin was planted with the use of Baliway.

TABLE 7.—*Planting by Baliway (Bakal, fifth stage).*

Caingin No.	Actual.				Computed per hectare.			
	Man-days.	Woman-days.	Expenses.	Yield.	Man-days.	Woman-days.	Expenses.	Yield.
				Cavans				*Cavans*
[a] 1				30.0				26.8
2	10	10	₱12.50	15.6	17.5	17.5	₱21.92	27.3
3	7	8	6.70	36.0	11.5	13.1	11.00	27.5
4	6	6	7.00	54.0	8.7	8.7	10.24	27.5
[a] 5				27.0				31.7
6	7	7	6.00	30.7	11.2	11.2	9.60	16.7
7				36.0				[b] 22.3
8	3	3	1.90	30.0	8.4	8.4	5.85	16.5
9				75.6				28.4
10				24.0				16.8
11								
12	3	3	2.50	11.4	21.3	21.3	17.76	20.4
13	19	19	45.00	72.0	7.5	7.5	17.78	28.5
[a] 14				9.6				14.0
M					12.3	12.53	13.38	23.41
					+ 1.22	+ 1.21	+ 1.89	+ 1.05
6					4.81	4.78	7.52	5.65
					+ 0.86	+ 0.86	+ 1.36	+ 0.75
C					39.10	38.15	56.20	24.13
					+ 8.04%	+ 7.77%	+12.86%	+ 3.34%

[a] This caingin was planted with the use of Balawang.
[b] Planted by contract.

TABLE 8.—*Summary of averages per hectare in Tables Nos. 2 to 6.*

Stages.	Per hectare.		
	Man-days.	Woman-days.	Expenses.
Preliminary clearing (Hawan, 1st stage)	24.3	.....	₱12.32
Felling and lopping of timbers (Hapay, 2nd stage)	15.9	.....	8.15
Cutting, collecting log, etc. (Dulok, 3rd stage)	20.3	.....	7.36
Preliminary weeding (Gusad, 4th stage)	.....	19.3	5.77
Planting: Average of Baliway and Balawang (Bakal, 5th stage)	8.7	11.7	14.85
Weeding	.....	16.0	7.56
Total	69.2	47.0	56.01

ILLUSTRATIONS

Plate 1

Tools used in caiñgin rice planting, Lamao, Bataan.

1. Tiyad.
2. Yatab or pang-ani, about x-1/2. Yatab, cross-section, above.
3. The baliway greatly reduced in size.
4. Detail of baliway.
5. The balawang greatly reduced in size.
6. Detail of balawang.

Plate 2

The planting of caiñgin rice by *baliway* method, Lamao, Bataan.
Note the musicians behind the planters.

1. First position, the baliway in the right hand.
2. Second position, the baliway in the left hand.

Plate 3

The planting of caiñgin rice by *balawang* method, Lamao, Bataan.

1. First position, the balawang leaning toward the right side while the women face on the opposite.

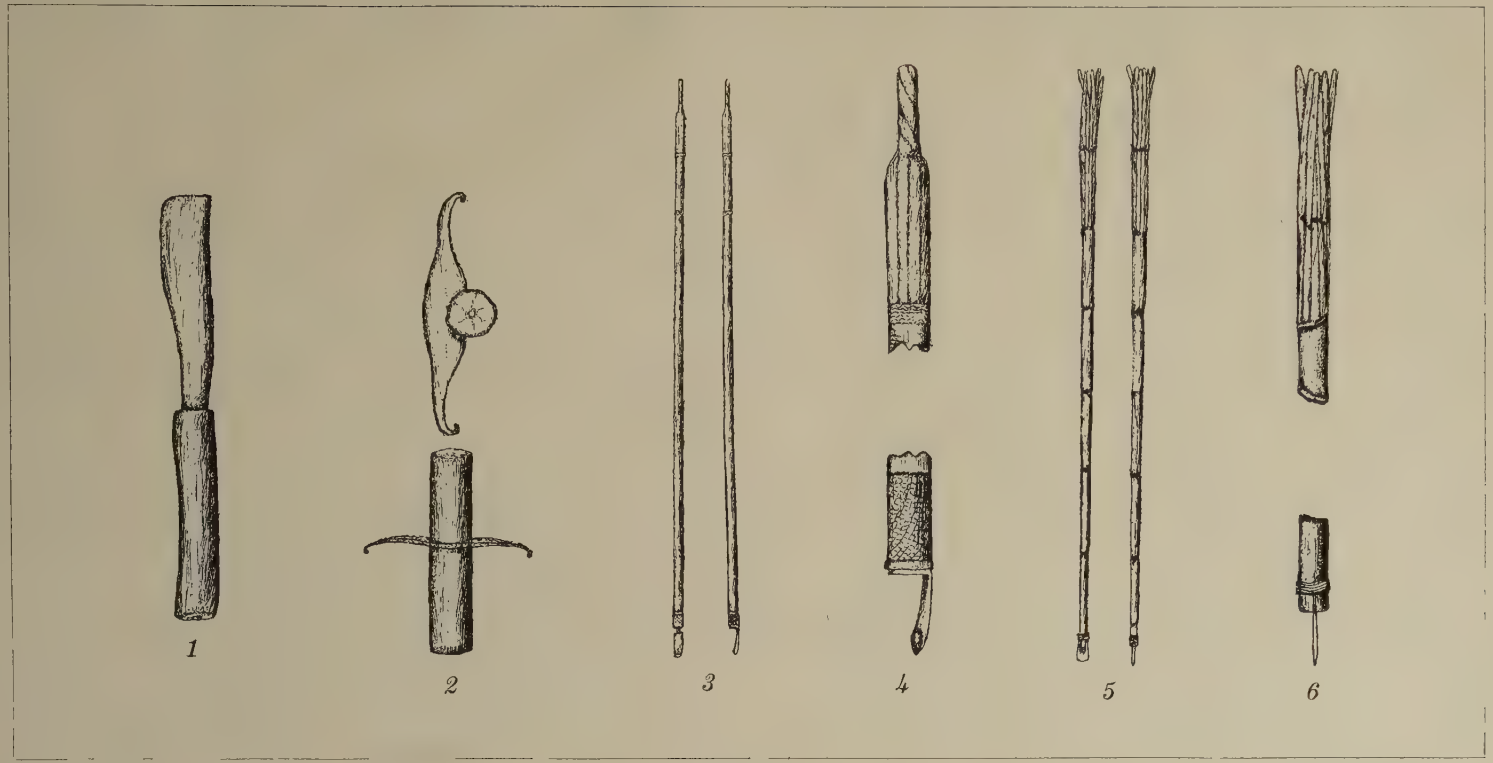

PLATE 1.

1

2

PLATE 2.

1

2

PLATE 3.

A PRELIMINARY STUDY ON THE ROTENONE CONTENT OF SOME DERRIS ROOTS COLLECTED FROM DIFFERENT PARTS OF THE PHILIPPINES.

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The value of derris roots as a source of rotenone, a potent insecticide which is harmless to man and to higher forms of animals, is now generally recognized. Since very early times, many Oriental peoples have used derris to poison fish and to control caterpillars.(3) Rotenone is effective both as a stomach and as a contact insecticide which causes no injury to the plant. Certain rotenone preparations are also used against fleas, lice etc.

In view of the growing commercial value of derris, its cultivation is attracting some attention. For the last few years the Bureau of Plant Industry has been receiving inquiries from manufacturers abroad, particularly from the United States, regarding the possibility of securing commercial quantities of derris roots of high rotenone content.

Some derris roots have always been exported from Malaya, but the supply has generally been less than the market demand. Table 1 shows the amount of derris roots exported annually from the Malay States. In 1930, the total exports amounted to 55.5 tons, and in 1931 this was increased to 74 tons.(4)

Table 1.—*Derris roots exported from the Malay States.*

Year.	Amount.	Malay currency.	U. S. currency.
	Lbs.	*Dollar*	*Dollar per lb.*
1926	54,540	24,175	0.248
1927	79,065	39,942	0.283
1928	80,236	27,357	0.190

The United States, importing more than 11,000,000 pounds of Pyrethrum flowers valued at about $2,500,000, should be a good

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market for this product.(8) Other countries in Europe and Asia which use large quantities of insecticides, may likewise be potential markets.

The American Chemical Society is directing its attention to the study of spray residues of arsenical insecticides on the leaves of the plants. As a result of these studies, the use of non-arsenical insecticides, such as rotenone, pyrethrum, etc., has been found to possess greater advantages.

POSSIBILITIES OF GROWING DERRIS IN THE ISLANDS FOR EXPORT

Derris is widely distributed throughout the tropics. Nearly fifty species are known. Merrill(6) claimed that fifteen or sixteen are growing wild in the Philippines. Of this number, only a few, like *Derris philippinensis* Merr., *D. elliptica* Benth. and *D.* sp., have been reported to contain the toxic principle present in sufficiently large quantities to make them useful.(3, 9)

Derris grows in most kinds of soils, although it prefers clayey loam containing a little amount of sand. In Cebu, P. I., derris is said to be grown profitably in worn-out lands where other crops can no longer thrive. It is usually planted on hill-sides. It adds soil fertility, prevents soil erosion, and serves as cover crop.(7)

The best results are obtained by ridging the soil. Cuttings, when planted on lands exposed to the sun, must have the leaves removed to protect the stem from drying due to excessive transpiration. Under light shade, the cuttings root early, usually within six weeks from the date of planting.

Georgi and Curtler (1929) reported that the root matures generally within 2 years, but the crop is usually not harvested at one time. The roots are simply lifted when harvested.(5) In Cebu, the roots are harvested after 3 years. The production is estimated at 2,500 to 3,500 kilos of fresh roots per hectare. No exact data on the yield of rotenone per plant nor yield of extractable roots per hectare are available for the present.

The Insecticide Division, Bureau of Chemistry and Soils, U. S. Department of Agriculture, has made a survey of tropical plants for the purpose of finding plant materials of value as insecticides.(8) As a result, Clark(8) reported the South American plant "cube" (pronounced coo-bay) to contain 7 per cent rotenone, which is higher than that of the derris roots here. This plant has been identified by Killip(8) as *Lonchocarpus nicou*

(Aubl) D. C. Other species of *Lonchocarpus* from British Guiana have been reported by several men to contain "tubatoxin" (another name for rotenone). Other plants reported to contain rotenone are *Milletia taiwaniana* Havata, *Mundulea suberosa* Benth. and *Ormocarpum* sp.(8)

Roark(8) of the Insecticide Division of the United States Department of Agriculture identified rotenone as a white crystalline material having the empirical formula $C_{23}H_{22}O_6$, and a melting point of 163° C. It contains one keto-group and two methoxyl groups. It is extremely insoluble in water, very slightly soluble in petroleum, ether, kerosene, and other petroleum hydrocarbons, slightly soluble in methyl, ethyl, n-propyl and n-butyl alcohols, soluble in benzol and acetone, and readily soluble in chloroform, ethylene dichloride, and trichlorethylene.

The name "tubatoxin" has been applied to this substance by Tattersfield and Roach (1922) who claimed it to be identical with "tubain" of Wray (1892) and with "derrid" of Sillvedolt (1899).(8)

Uichanco (1933) made a chemical study of three species of Philippine derris; namely, *Derris elliptica* Benth, *D. philippensis* Merr., and *D.* sp., which contained 0.004, 0.906 and 2.457 per cent rotenone, respectively.(9) An insecticide test of these crystals on aphids (*Toxoptera aurantii* Boyer), was subsequently performed by the same author. From the results of her studies, she concluded that the actual effectiveness of *D.* sp. is 57 per cent, of *D. philippensis,* 31 per cent; and of *D. elliptica,* 39 per cent. There seems to be a close correlation between the amount of rotenone contained in the root and inseticidal efficiency, that is, the higher the content, the greater the efficiency.

PURPOSE OF INVESTIGATION

It has been observed by all investigators that not all species of derris have the active principle, rotenone. Some species have it high in a high degree, others in a very low degree or just a trace, while still others contain no rotenone at all.

This investigation was undertaken to analyze the representative derris roots collected from different parts of the Philippines for their rotenone content.

MATERIALS

The derris root samples used in this study were collected from different parts of the Philippine Islands by the district agronomists of the Bureau of Plant Industry.

The samples, arranged in the same order as in Table 2, are as follows:

Ac–33–216—Cebu, Cebu.—Known as "tubli," a creeping or climbing vine; usually cultivated in wornout lands; planted by cuttings, giving approximately 2,500 to 3,500 kilos of roots per hectare. Used as fish poison.

Ac–33–129—Occidental Misamis.—No information available.

Ac–33–115—Talisay, Cebu.—Known locally as "ikog-ilaga." A creeping or climbing vine, usually cultivated, with an approximate yield of 300 kilos of roots per hectare.

Ac–33–135—Oriental Misamis.—No information available.

Ac–33–136—San Rafael, Camarines Sur.—Known locally as "toble-lono." A creeping plant on trunks of living trees like *nanka* (jak). Cultivated on very small scale, usually planted in the backyards of houses near rivers or creeks.

Ac–33–103—Guinobatan, Albay.—No information available.

Ac–33–108—Silang, Cavite.—Planted in the backyards to the extent of one plant per yard. No other information available.

Ac–33–84–a—San Fernando, La Union.—Locally known as "ba-ot," a creeping plant, growing wild in forests along the brooks. Whitish in color, used as fish poison.

Ac–33–114—Talisay, Cebu.—Another derris plant known as "tibaun;" semi-wild, with creeping or climbing habit.

Ac–33–112—No information given.

Ac–33–132—Calamba, Laguna.—Known locally as "tubli." Collected in the barrio of Makiling, Calamba. A creeping or climbing plant, growing wild, but planted by some people in limited numbers along fences in the backyard.

Ac–33–134—Cagayan, Oriental Misamis.—Known as "doles." No information available.

Ac–33–109—Silang, Cavite.—Collected in Iba, Silang, Cavite; cultivated, but only a single plant to a home owner. Known locally as "tubli."

Ac–33–84–b—Alilem, Ilocos Sur.—Locally known as "ba-ot." A creeping or climbing plant; growing wild in the forest. Brownish in color, flowers in November or December. A single plant cultivated in a backyard. No other information available.

Ac–33–102—Lamao Expt. Station, Lamao, Bataan.—Collected in Lamao, Bataan. No other information available.

Ac–33–110—Silang, Cavite.—Collected at Pulong-buñga, Silang, Cavite. Cultivated; a single plant to an owner. Known as "tubli."

Ac–33–116—Samal, Davao.—Collected in Samal, Davao. A climbing plant, growing wild, known locally as "tuble." No other information available.

Ac–33–81—Calapan, Mindoro.—Collected in Calapan, Mindoro. Known locally as "tubli." Growing wild; flowers and bears pods in August. No other information available.

METHODS

Preparation of the sample.—The derris roots received were cleaned and freed from mud and other extraneous matter. About a kilo each of representative samples of roots were cut by means of a tobacco cutter. The shredded roots were kept at about 70° C. until sufficiently dry for grinding. They were then ground repeatedly and passed through a 20-mesh sieve. These samples were mixed thoroughly and placed in well stoppered bottles.

Moisture.—About 5 grams of each sample were placed in a tared porcelain crucible and dried in an electric oven at 100° C. for about 8 hours or until constant weight was obtained. The loss in weight of the sample expressed in percentage is reported as the moisture content.

Ether extract.—About 15 grams of each sample were placed in an extraction thimble and dried in the electric oven to constant weight. By the use of Soxhlet's apparatus, the sample was extracted with ether for 16 hours. The ether in the tared extraction flask was distilled completely and the residue dried in the oven at 70° C. to constant weight. The increase in weight of the flask expressed in percentage is reported as the ether extract.

Crude rotenone.—The ether extract was dissolved in a sufficient amount of ether and transferred into a test tube. The flask was washed repeatedly with ether and the washing were added to the dissolved extract in the test tube. The combined extract and washings were concentrated somewhat at 36° C. and kept in the refrigerator overnight. The next day the test tube was subjected to ordinary conditions for 5 hours to make the ether mobile. It was again cooled in the refrigerator for about thirty hours and the crude rotenone filtered through filter paper in a tared gooch crucible. The residual crystals were washed successively with two-10 cc. portions of cooled ether and then dried in the oven at 70° C. to constant weight. The weight of the dried residue expressed in percentage is taken as the crude rotenone content of the sample.

RESULTS

The results of the analyses of twenty-one samples of derris roots for rotenone are given in Table 2. They are classified according to their respective yields of rotenone, as high yielding,

TABLE 2.—*Showing the analysis on rotenone content of derris roots collected from different parts of the Philippines*

Accession number	Placed of collection	Local names	Size of roots analyzed [1]	Moisture	Analysis				Approximate yield of rotenone per ton of roots
					Ether Extract		Crude Rotenone		
					Dried at 70° C	Moisture free basis	Dried at 70° C	Moisture free basis	
				Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Kilos per ton*
			HIGH YIELDING [2]						
216	Cebu, Cebu		Medium	7.03	16.29	17.32	2.25	2.42	24.2
129	Occidental Misamis		do	3.71	12.64	13.13	1.63	1.69	16.9
115	Talisay, Cebu	Ikog-ilaga	do	6.62	17.68	18.93	0.79	0.85	8.5
135	Oriental Misamis		do	3.21	9.39	9.70	0.79	0.82	8.2
136	San Rafael, Camarines Sur	Toble-lono	do	3.24	4.47	4.62	0.57	0.59	5.9
			MEDIUM YIELDING [3]						
103	Guinobatan, Albay	Lono	Medium and small	7.56	12.76	13.80	0.39	0.42	4.2
109	Silang, Cavite	Tubli	Medium	2.41	15.85	16.24	0.36	0.37	3.7
84–a	San Fernando, La Union	Ba-ot	Big and medium	7.96	5.79	6.29	0.21	0.23	2.3
114	Talisay, Cebu	Tiba-un	Medium	2.80	3.78	3.89	0.21	0.22	2.2
112	(Sent by Mr. Medrano, no information given).	Tubli	Small and medium	7.70	4.80	5.20	0.15	0.16	1.6
132	Calamba, Laguna	do	do	2.94	5.51	5.68	0.15	0.15	1.5
134	Cagayan, Oriental Misamis	Doles	Medium	5.47	4.16	4.40	0.09	0.10	1.0
109	Silang, Cavite	Tubli	Medium and small	5.51	5.37	5.68	0.09	0.10	1.0

			LOW YIELDING[4]					
84–b	Alilem, Ilocos Sur	Ba-ot	Medium	6.84	5.94	6.38	0.08	0.09	0.9
102	Lamao, Experimantal Station, Lamao, Bataan.		do	5.73	1.80	1.91	0.078	0.083	0.83
110	Silang, Cavite	Tubli	do	6.97	2.65	2.85	0.06	0.072	0.72
116	Samal, Davao	Tuble	Medium	4.06	4.23	4.41	0.05	0.052	0.52
81	Calapan, Mindoro	do	do	15.04	7.23	8.51	0.03	0.035	0.55
81	do	do	Small	8.62	7.85	8.59	0.05	0.055	0.35
81	do	do	Big	12.03	6.55	7.45	0.02	0.023	0.23
111	Dasmariñas, Cavite	do	Big and medium	6.31	3.22	3.44	0.04	0.043	0.43

[1] Small, less than 1 centimeter in diameter; medium, from 1 to 1½ cm. in diameter; big, from 1½ to 2½ cm. in diameter.
[2] Those that yield from 0.5 per cent and above moisture free, crude rotenone.
[3] From 0.1 to 0.5 per cent moisture free, crude rotenone.
[4] From 0.1 per cent and below.

from 0.5 per cent and above; medium yielding, from 0.1 to 0.5 per cent; and low yielding from 0.1 per cent and below. Only five samples contain appreciable amounts of rotenone, the rest are poor yielders.

Derris roots from Calapan, Mindoro were classified into three sizes, big, medium, and small. Separate analyses were made. The results show that the smaller roots contain more rotenone than the bigger ones.

The accompanying illustration shows the extraction apparatus used in our trial to extract rotenone crystals from fresh derris roots in a semi-commercial process. Solvents like trichlorethylene and carbon tetrachloride were used, but the percentage of rotenone extracted was very low, 1.41 per cent with trichlorethylene and 1.79 per cent with carbon tetrachloride. The objections to this apparatus are that there is too much loss of the solvents, there is no thorough extraction of the sample; and very inflammable solvents like ether and acetone are not safe to use.

Derris samples collected from Cebu, Cebu, contain 2.42 per cent crude rotenone; from Occidental Misamis, 1.69 per cent; from Talisay, Cebu (known as Ikog-ilaga), 0.85 per cent, from Oriental Misamis, 0.82 per cent, and from San Rafael, Camarines Sur (known as toble-lono), 0.59 per cent. All these roots from one to one and one-half centimeters in diameter were classified as medium in size.

These species, having been found to give high yields of rotenone, are to be recommended for propagation on a commercial scale. The derris samples collected in the southern part of the Archipelago apparently contain more rotenone than samples collected elsewhere. All samples classified under high yielding varieties with the exception of one (the one coming from San Rafael, Camarines Sur) are from Cebu and Misamis.

Table 2 shows that the approximate yields of rotenone per ton of roots of each variety is quite low. The strength of the rotenone crystals is so tremendous, however, (Davidson) (8), that one gram dissolved in 300 liters of water is enough to control the bean aphid effectively. This rate of effective application materially compensates the high expense of extraction. The other desirable qualities of rotenone as mentioned above must also be remembered in considering the high cost of extraction.

Saldaña(11) of the staff of the Bureau of Plant Industry reports that an average of 600 kilos of dried derris roots can be obtained from one hectare (a decidedly low estimate) and can be sold at a minimum price of ₱360 per hectare after three years. The cultivation and harvesting expenses would perhaps not be high since the plant does not need much attention. But assuming that the root crop is to be exported as it is, the income would be very much reduced as the cost of shipment to the United States is quite high.

If, however, the rotenone is extracted right where it is grown, the cost of shipment would be greatly minimized, since 600 kilos of dried derris roots will yield about 14.52 kilos only of crude rotenone crystals. Moreover, should not extracted rotenone bring a higher price than the same amount still in the roots, at the ratio of 24.2 kilos of rotenone per ton of roots (Table 2). If shipment to the United States costs ₱0.30 per kilo, then only ₱4.50 would be the shipment charge for the total 600 kilos of dried roots converted into rotenone, as compared with ₱180 for the roots.

The expense of extraction can be kept low to enable the planter or manufacturer to realize a reasonable gain in the enterprise.

SUMMARY

1. Unlike some derris species of other countries which do not contain rotenone,(8) all Philippine derris samples analyzed contain rotenone, although only a few contain relatively high quantities of this insecticide.

2. The derris samples from Misamis and Camarines Sur are high yielding; those from Albay, Cavite, La Union, Laguna, and some samples from Cebu and Misamis, give medium yields; while those from Ilocos Sur, Bataan, Davao, Mindoro, and some from Cavite contain very little crude rotenone.

3. Results of this study seem to confirm the reports of other workers that small roots, at most one centimeter in diameter, contain a greater quantity of the active principle than the bigger roots.

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NOTES ON A SUSPECTED "MOSAIC" OF ABACÁ IN THE PHILIPPINES [1]

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ONE PLATE

In March, 1933, the writer was detailed to the province of Davao to launch a general eradication campaign against abacá bunchy-top. This work offered a good opportunity to make extensive field observations not only of the bunchy-top but other diseases of abacá in all of the important abacá districts in Davao. During the field surveys a mosaic-like disease of abacá hitherto unreported in the Philippines was found. The disease was first observed in the Odell Plantation,[2] municipal district of Tagum, Davao in March 7, 1933. Later it was also noted in various abacá plantations in the municipality of Davao, the municipal district of Guianga, the municipality of Santa Cruz, and the municipal district of Pantucan.

The disease possesses all the characteristic aspects of a mosaic, hence it is provisionally referred to as "mosaic disease." The most visible symptom is the conspicuous mottling of the leaves (Plate 1, figs. 1 and 2). The mottled areas are composed of streaks of green or yellowish pale green which are manifested on both sides of the infected leaf, and on the midrib and petioles (Plate 1, figs. 1 and 2). On the other hand, a normal leaf appears green with a more or less uniform distribution of the chlorophyll (Plate 1, fig. 3). The elongated yellowish-pale green streaks running parallel with the veins may extend from the midrib to the margin of the leaves. In some cases these streaks are broken, and, therefore, no true stripping is produced (Plate 1, figs. 1 and 2). The intensity of mottling depends to a certain degree upon the stage of the disease. In the early stage of infection the green color on the leaves is more dominant than the yellowish pale green but as the disease gets old the yellowish pale color becomes very prominent. The mottling may be noted

[1] Work done in the Plant Pathology Section with the coöperation of the Fiber Research Section.

[2] The author wishes to express his gratitude to Mr. E. G. Goldsborough, Manager of the Odell Plantation for his coöperation, and to Mr. Anastacio de la Cruz for information and help in the field experiments.

also on the unfolded young leaf of a diseased plant. From the time the symptoms appear, the leaves subsequently produced are mottled. The abacá plant may be attacked in all stages of its growth. Small newly sprouted suckers when infected may show the characteristic symptoms of the disease. With late infection, it was observed that the diseased plant may not become stunted, the leaves may have the normal breadth and may not exhibit any decided bunchy growth. On the other hand, early infection may cause stunted growth or partial dwarfing of the plant. Diseased plants do not show any tendency to recover. Some may die a premature death, others, however, continue to grow to a fruiting stage.

With the exception of some minor variations in symptoms this disease of abacá is similar to, if not identical with, the new virus disease of bananas reported by Magee (1930) in New South Wales.[3] The same author also reports the infectious nature of the new virus disease of bananas by transferring the banana aphid (*Pentalonia nigronervosa*) from diseased to healthy plants. Although preliminary attempts to transmit the so-called mosaic disease of abacá have proved negative further experiments seem necessary before definite conclusions can be made.

At present the disease is sporadic in occurrence and the damage is rather slight as compared with the abacá bunchy-top and stem-rot, but apparently it affects the normal growth of the plants and may also reduce the yield to a certain degree. Actual counts of 36 mosaic infected hills in the Odell Plantation have shown that infection ranges from 7.69 per cent to 100 per cent.

In a series of trials conducted in the field it was found that the mosaic is carried over to new plantings by the asexual method of propagation and then is spread by the planting of either mosaic infected suckers or suckers from diseased stools. Satisfactory results have been obtained in our attempt to control the spread of the disease by roguing and burning all the mosaic infected hills in the Odell Plantation. With this method no progress of the disease has been noted even among the neighboring plants at very close range. This information may be useful to the abacá planters in controlling the disease. It is, therefore, suggested that the abacá plants for planting purposes be taken from fields absolutely free from the mosaic disease. Further investigation of this disease is in progress.

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[3] Magee, C. J. 1930. A new virus disease of bananas. Agricultural Gazette of New South Wales. 41: (1930) 929.

ILLUSTRATIONS

Plate 1

1. A young abacá leaf infected with the mosaic disease. Note the characteristic mottling on the lower surface of the leaf-blade and also on the midrib.
2. Upper surface of the same leaf shown in figure (*a*) showing the characteristic mottling on the leaf-blade and also on the midrib.
3. A normal leaf of a young abacá plant. Note the uniform distribution of the chlorophyll.

All photographed by the Department of Agriculture and Commerce, Division of Publications, Manila, P. I.

1 2 3

PLATE 1.

A SCLEROTIAL STEM ROT OF EVERLASTING, *HELICHRYSUM BRACTEATUM* WILLD

By GAUDENCIO M. REYES

Of the Bureau of Plant Industry, Manila

ONE PLATE

After the first heavy rains of June, 1934, in a garden in Manila, full-grown everlasting plants (*Helichrysum bracteatum* Willd.) bearing flowers were found to be suffering from a certain fungus attack at the base of the stem causing wilting shortly after infection. Examination showed that the infection and blackening of the basal portion of the stem was caused apparently by a soil fungus of the genus *Sclerotium*, which later proved to be *S. rolfsii* Sacc. This seems to be the first report of the occurrence of this fungus on everlasting, although outbreaks of the same fungus on other ornamental plants, such as larkspur, carnation, amarylli lily, Watsonia, petunia, Amazon lily and "buñga de China" *Adonidia merrillii* (Becc.) Becc.[1] have already been reported in the Philippines. Cockscomb (*Celosia crestata* Linn.), a common herbaceous ornamental, has also been successfully infected artificially and found highly susceptible to *Sclerotium rolfsii* by Ramos.[2]

The first noticeable symptom of the disease is the wilting (Plate 1, *a*) of the plant from the tip down. Wilting, however, is preceded by the attack of the fungus at the base of the plant through the soil, which is first made evident by lesions having a water-soaked appearance and, later, by the blackening (Plate 1, *b*) and disintegration of the cortex below and above the ground level. Dense, white, fluffy mycelium (Plate 1, *b*), may be observed growing up and around the stem, while small, white, light yellow or light buff and then brown, smooth, spherical bodies (see arrow) which develop later may be seen at the base

[1] Fajardo, T. G. Sclerotium stem rot of delphinium and other ornamental plants in Trinidad Valley, Mountain Province, Philippine Islands. Philip. Journ. Sci. 51 (1933) 447–456.

[2] Ramos, J. C. Pythium damping-off of seedlings. Philip. Agrst. 15 (1926) 85–97.

of the plant and on the soil immediately surrounding the stem. The healthy upper portion of the stem gradually withers away and the plant dies.

On splitting the stem, the pith within the level of infection (Plate 1, *b*) was found to be darkened by the penetration of the fungus mycelium, which had gradually disintegrated and shrunk it. The woody portion was discolored and a hollow in the stem was produced up to the point of infection due to the rotting of the pith. Decay took place and a smell similar to that of certain mushrooms was produced by the rotted portion.

The roots, however, were not directly attacked by the fungus. It is certain, then, that the disease is spread either from plant to plant on the surface or through the soil, or through dead or living hosts or decaying plant tissues.

Pure cultures of the fungus were readily prepared from sclerotial bodies found adhering to the base of the stem, and the fungus proved to be similar in cultural and mycelial characters as well as in color, size, and shape of sclerotia, to those found and isolated previously by the writer from peanut or groundnut, rice, wheat, onion, "bunga ñg tubo" (*Aeginetia indica* Linn.), eggplant, and other more or less important crop plants. Sclerotia are produced abundantly, dotting the surface of the medium, spherical to ovoid in shape, changing in color during growth from white to brown. Usually during growth the sclerotia are covered with crystal to brownish water-droplets. These sclerotia are easily detached, and when mature, resemble mustard seeds in size. Some sclerotia fuse at the sides, assuming various shapes and sizes. As the sclerotia reach maturity, the downy covering sloughs off, becoming darker brown in color, smooth, and somewhat shiny.

The fungus is distinguishable by certain characteristics in the mycelium by the presence of clamp connections, by the peculiar and more or less parallel branching, by the presence of clamp connections at the septa, and by the branching from one of the clamp connections. Anastomosing of branches also occurs. Compared with typical and authentic cultures of *Sclerotium rolfsii* Sacc., kindly supplied by Dr. B. B. Higgins, Botanist, of Georgia Experiment Station, United States, the *Sclerotium* associated with everlasting (*Helichrysum bracteatum* Willd.) corresponds in every respect with *S. rolfsii* and agrees with

Higgins' morphologic studies [3] in many typical features of the mycelium and sclerotia, as well as in distinctive characters of growth as described by Taubenhaus,[4] thereby establishing its identity. As far as the writer is aware, the everlasting, together with "buñga ñg tubo" (*Aeginetia indica* Linn.) a destructive plant parasite of sugar cane and banana, are new additions to the already long list of hosts of *Sclerotium rolfsii* Sacc., recorded here and in other countries.

The plants attacked seem to have no chance of recovery. The healthy upper portion of the stem may be cut into pieces and planted in non-infected soil to replace dead plants. Tops with some of lower leaves plucked or cut to the base would also grow. Of course cuttings from healthy plants would be much better to propagate.

The control of this disease is practically the same as that in vogue for other economic plants attacked by this common soil fungus. In mild outbreaks and in small plantings, however, a good precautionary measure would be to ball out diseased plants as soon as noticed to about nine inches deep and six inches around the plant or further, beyond the visible mycelial ramifications of the fungus, and to replace the hole with sterilized soil, or soil known to be free from the disease. The diseased plants may be dumped into a pit and burned, or just allowed to dry in the sun. Other equally important measures to follow would be the prevention of the spread of the fungus to uninfected places; the practice of clean culture; the avoidance of close planting, especially in infested soils; and the shunning of rotation of plants which are liable to the ravages of this cosmopolitan soil-inhabiting organism. As time permits, or when it becomes necessary in case of severe outbreaks, control studies may be carried on further.

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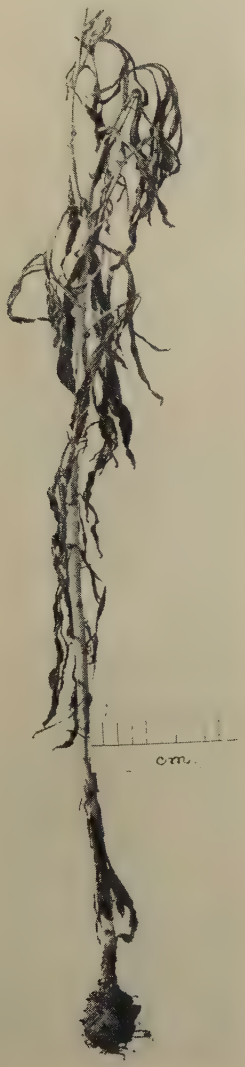
[3] Higgins, B. B. Notes on the morphology and systematic relationship of *Sclerotium rolfsii* Sacc. Journ. Elisha Mitchell Sci. Soc. 37 (1922) 167–172.

[4] Taubenhaus, J. J. Recent studies on *Sclerotium rolfsii* Sacc. Journ. Agric. Res. 18 (1919) 127–138.

ILLUSTRATIONS

Plate 1

1. An everlasting plant showing wilting and gradual withering of the stem due to the attack of *Sclerotium rolfsii* Sacc.; about × 0.02.
2. A close view of the base of an infected plant showing blackening of the cortex, the presence of a thick mat of white mycelium spreading up and covering a part of the stem, and the presence of sclerotia dotting the base (pointed out by arrow); about × 0.8.



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2

PLATE 1.

INDEX

A

Abacá in the Philippines, a suspected "mosaic" of, 255; further studies on the stem-rot of, 191.
Actinomyces scabies (Thox.) Guer., 225.
Adcock, 74, 83.
Adonidia merrillii (Becc., 259.
ADRIANO, F. T., The cultivation, toxic constituents, uses, chemical analysis and extraction of derris, 1.
ADRIANO, F. T., and D. P. TABIJE, The relative efficacy of different storage solutions for the preservation of natural color Philippine plant material for exhibition purposes, 157.
ADRIANO, F. T., A. VALENZUELA, E. C. YONZON, and C. G. RAMOS, The handling of some Philippine fruits with special reference to the ethylene, borax, and paraffin treatment, 87.
ADRIANO, F. T., S. B. OLIVEROS, D. S. SANTOS, and E. R. VILLANUEVA, The physical characteristics and chemical composition of various brands of toyo (soy sauce) sold in the Philippines, 171.
ADRIANO, F. T., S. B. OLIVEROS, D. TABIJE, and F. CRISOSTOMO, A preliminary study on the rotenone content of some derris roots collected from different parts of the Philippines, 245.
Aeginetia indica Linn., 260, 261.
AGATI, JULIAN A., MELANIO R. CALINISAN, and VICENTE C. ALDABA, Further studies on the stem-rot of abacá in the Philippines, 191.
ALDABA, VICENTE C., *see* AGATI, CALINISAN, and ALDABA.
Alicano, 78.
Al-langigan, 78.
Alternaria, 145.
  brassicae (Berk.) Sacc., 148, 149.
  herculea (Ell. and Mart.) Elliot, 143–146, 148–150, 152.
  solani (Ell. and Mart.) L. R. Jones and A. J. Grant, 225.
American celery, 31.
Ani, 235.
Antolin, 78.
Aphids, 247.
  banana, 256.
  cabbage, 3.
Aphis marosiphum, 3.
  pomi De G., 3.
  rudbeckia, 3.
  rumicis, 3.
  sorbi Kolt., 3.
  spiraecola, 3.
Apium graveolens L., 31.
  graveolens L. var. dulce, 31.
  graveolens L. var. rapaceum DC., 32, 38.
Arkadia Tyek Kulok, 74.
Armoracia rusticana Gaertn., 144, 145.
Asparagus plumosus, 3.
Aspergillus, 184.
  flavus-oryzæ, 174, 175.

B

Bacari, 78.
Bahia, 74.
Bakal, 234, 240.
Bakanae, 124, 127, 128.
Baker's Sumatra, 74.
Baliwang, 234, 235.
Baliway, 234, 235.
Bambusa spinosa Blco., 234.
Banana black-tip disease in the Philippines, 117.
Bansuroy, 78.
Baot, 2, 248.
Barili, 78.
Barocana, 78.
Baset, 2.
Batec, 73, 78.
Batoli, 74.
Beans, common, 173.
  lima, 173.
  mongo, 173.
  soy, 173, 174.
Berlin, 78.
Big Warne, 83.
Bilao, 177.
Blumenstiel, 73.
Boho, 234.
Brachysporium torulosum, 117.
Brassica oleracea var. botrytis Linn., 144.
  oleracea var. capitata Linn., 143.
  pekinensis Rupr., 143.
  rapa Linn., 144.
Broodleaf, 73.
Buñga de China, 259.
  ñg tubo, 260, 261.

C

Cabbage, Wongbok, and other cruciferous plants in Trinidad Valley, Mountain Province, Luzon, a serious leaf spot of Chinese celery, 143.
Cacite ñga Lubay, 78.
Cacites, 78.
Cagayan, 78.
Caiñgin rice, 231.
CALINISAN, MELANIO R., *see* AGATI, CALINISAN, and ALDABA.
Calopogonium, 59.
Capigued, 78.
Carrot, 38.
Carum petrosclimum B. and H., 38.
Catch-crop, 232.
Cauliflower, 144.
Celeriae, 32, 38.
Celery, two destructive leaf diseases of, in the Philippines, 31.
Celosia crestata Linn., 259.
Centrosoma, 59.
Cercospora apii Fres., 39, 41.
musarum Ashby, 117.
personata, 66.
Ch'an yau, 171.
Chiang yoo, 171.
Chinese celery cabbage, Wongbok, a serious leaf spot of, 143.
Cockscomb, 259.
Coffee, excelsa, 17.
Common beans, 173.
Connecticut Havana, 73.
Round tip, 73, 74.
Seedleaf, 73.

D

Darulug, 74.
Daucus carota L., 38.
Derries, the cultivation, toxic, constituents, uses, chemical analysis, and extraction of, 1.
roots collected from different parts of the Philippines, a preliminary study on the rotenone content of some, 245.
Derris elliptica Benth., 2, 4, 6, 10, 246, 247.
malaccensis, 2, 10.
philippinensis Merr., 246, 247.
sp., 246, 247.
Dinber, 74.
Dinumero, 78.
Doles, 248.
Dulok, 233, 239.
Dumbara, 73.
Dutch, 74.

E

Early blight, 31.
EJERCITO, JUAN M., Peanuts in the Philippines, 47.
Espada, 74, 78, 82.
EVARISTO, GAUDENCIO, *see* LUISTRO and EVARISTO.
Everlasting, Helichrysum bracteatum Willd., a sclerotial stem rot of, 259.
Excelsa coffee, the effect of mulching on the yield of, 17.

F

FAJARDO, T. G., *see* PALO and FAJARDO.
FAJARDO, T. G., and M. A. PALO, A serious leaf spot of Chinese celery cabbage Wongbok, and other cruciferous plants in Trinidad Valley, Mountain Province, Luzon, 143.
Florida Sumatra, 73.
Fortheimer, 74.
Friedrichsthaler, 74.
Frisbie, William G., 121.
Fruits, Philippine, 87.
Fusarium, 123–130, 132, 134–138, 226.
moniliforma Sheld., 127.
moniliforme var. maius Wr. and Rg., 127, 128.

G

Gamas, 235.
Gaudertheimer, 74.
Germination of the pollen of rice and pollentube growth, 21.
Gibberella fujikuroi (Saw.), 128.
moniliformis (Sheld.) Wineland, 127.
saubinetii, 127.
Glocosporium, 194, 197.
Gloria, 117.
Goldleaf, 74.
Groundie, 74.
Gusad, 233, 239.

H

Habichuelas, 173.
Hapay, 233, 238.
Harinapali, 74.
Havana, 73, 74.
Havanensis, 73, 74.
Hawan, 233, 238.
Helichrysum bracteatum Willd., 259, 260.
Helminthosporium, 118, 192, 196–198, 202, 204.
gibberosporum, 192.
maydis, 196.
torulosum (Syd.) Ashby, 117, 118, 198, 202, 204, 206.
turcicum, 196.
Hockanum Seedleaf, 74.
Horse-radish, 143, 145.
Howells White Burley, 74.

I

Ikog-ilaga, 248.
Ilagan Sumatra, 82.
Iloilo, 78.

Indigofera, 59.
Irish potato culture in the Philippines, 213.
Isabela, 78.
Ixora finlaysoniana Wall., 27.

J

Jamaica, 74.
J. Kelly White Burley, 74.
John William Seedleaf, 74.

K

Kaing, 176.
Kaviteño, 78.
Kidney beans, 173.
Kinchay, 31.
Kovalha, 74.

L

Lagtang, 2.
Lapondan, 78.
Late blight, 31.
Latundan, 117.
Leaf diseases of celery in the Philippines, 31.
Lima beans, 173.
Limmogo, 78.
Lisea fujikuroi, 127, 128.
(Gibberella) fujikuroi, 127.
Lonchocorpus, 247.
nicon (Aubl) DC., 247.
Longleaf Goosh, 74.
Lono, 2.
Luetzer's White Burley, 74.
LUISTRO, F. D., and GAUDENCIO EVARISTO, The effect of mulching on the yield of excelsa coffee: A progress report for 1930–1933, 17.

M

Macrosporium, 145.
herculeum (Ell. and Mart.), 144–146.
Malasiag, 2.
Man rice, 124.
Mandbatta, 74.
MANIO, RAMON V., Caiñgin rice, 231.
Manyleaf Sonlouk, 74.
Marogui, 73, 82.
Maryland Mammunsth., 74.
Milletia taiwaniana Havata, 247.
Mongo beans, 173.
Morada, 78.
Mundulea suberosa Benth., 247.
Musa cavendishi Lamb., 117, 198.
supientum Linn., 117.
sapientum var. cinerea (Blco.) Teodoro, 117.
sapientum var. compressa (Blco.) Teodoro, 117.
sapientum var. ternatensis (Blco.) Teodoro, 117.
Mycosphaerella brassicicola (Fr.) Lindau, 148.

N

Narturtium armoracia Fr., 145.
National Research Council of the Philippine Islands, the, 105.
Nicotiana tabacum, 72.
North Caroline Bright Yellow, 74, 83.

O

OLIVEROS, S. B., *see* ADRIANO, OLIVEROS, SANTOS, and VILLANUEVA; *see also* ADRIANO, OLIVEROS, TABIJE, and CRISOSTOMO.
Olsen No. 2, 73.
Orinoco, 73.
Ormocarpum sp., 247.

P

PAGUIRIGAN, DOMINGO B., Present Philippine standard varieties of tobacco, 71.
Pak yau, 171.
PALO, M. A., *see* FAJARDO and PALO.
PALO, M. A., and T. G. FAJARDO, Two destructive leaf diseases of celery in the Philippines, 31.
Pampano, 74, 78, 82.
Pang-ani, 235.
Pangasinan, 78.
Parsley, 38.
Parsnip, 38.
Pastinaca sativa L., 38.
Patis, 171.
Peanuts in the Philippines, 47; varieties of, 50; description of varieties of, 51.
Pentalonia nigronervosa, 256.
Phytophthora, 194.
Philippine Baker Sumatra, 73, 82.
Philippine fruits, the handling of some, with special reference to the ethylene, borax, and paraffin treatment, 87.
plant material, the relative efficacy of different storage solutions for the preservation of natural color in, for exhibition purposes, 157.
Phytophthora infestans (Mont.) De By., 225.
Plant material, Philippine, for exhibition purposes, 157.
Platana Arcadia, 74.
Potato, Irish, 213.

Q

Quarterly notes, 105, 187.

R

Radish, 144.
RAMOS, C. G., *see* ADRIANO, VALENZUELA, YONZON, and RAMOS.
Raphanus sativus Linn., 144.
Red Burley, 74.
Rejuvenation, 232.
Renta-Pugot, 78.

Repollo, 78, 82.
REYES, GAUDENCIO, M., Germination of the pollen of rice and pollentube growth, 21; Banana black-tip disease in the Philippines, 117; A new or little-known rice disease occurring in the Philippines, 123; A sclerotial stem-rot of everlasting, Helichrysum bracteatum Willd., 259.
Rhopalosiphum pseudobrassica, 3.
Rice, caiñgin, 231.
Rice disease occurring in the Philippines, a new or little known, 123.
Rice, germination of the pollen of, and pollentube growth, 21.
Ring spot, 148.
RODRIGO, PEDRO A., Irish potato culture in the Philippines, 213.
Romero, 73, 74, 78, 82.
Rotenone content of some derris roots collected from different parts of the Philippines, a preliminary study on the, 245.

S

Saba, 117.
Salopingpingan, 78.
Samson, 74.
Bafra, 82.
Samsoun Bafra, 74.
Santán, 27.
SANTOS, D. S., *see* ADRIANO, OLIVEROS, SANTOS, and VILLANUEVA.
Schizostachyum lumampao Blco., 234.
Sclerotium, 259.
rolfsii Sacc., 259.
Septoria, 33.
apii (Br. and Cav.) Chester, 33.
apii-graveolentis Dor., 34, 41.
Shoyu moromi, 171.
Siate, 78.
Simmaba, 78.
Solanum tuberosum L., 213.
Soy beans, 173, 174.
sauce, 171.
Spanish, 74.
Stand-up White Burley, 74.
Stand White Burley, 74.
Stem-rot of abacá in the Philippines, further studies on the, 191.
Stewart Cuban, 74.
Storage solutions for the preservation of natural color in Philippine plant material for exhibition purposes, relative efficacy of, 157.
Sumatra, 73.

T

TABIJE, A., *see* ADRIANO, OLIVEROS, TABIJE, and CRISOSTOMO; *see also* ADRIANO and TABIJE.
Tal zimmer, 74.
Ternate, 117.
Tettalay, 78.
Tibalan, 2.
Tibanglan, 2.
Tiklis, 176.
Tiyad, 235.
Tobacco, present Philippine standard varieties of, 71.
Toble-lono, 2, 248.
Tordan, 117.
Toxoptera aurantii Boyer, 247.
Toyo (soy sauce) sold in the Philippines, the physical characteristics and chemical composition of various brands of, 171.
Trebizond, 74.
Tubatoxin, 247.
Tuble, 2, 248.
Tubli, 2, 248.
Tubliti bauon, 2.
Tugli, 2.
Tugling pula, 2.
Turkish, 74.
Turnip, 144.

U

Upei, 2.
Upland, 232.

V

VALENZUELA, A., *see* ADRIANO, VALENZUELA, YONZON, and RAMOS.
VILLANUEVA, E. R., *see* ADRIANO, OLIVEROS, SANTOS, and VILLANUEVA.
Virginia Bright, 74.
Vizcaya, 73, 74, 82.
Vuelta abajo, 73.

W

Waraoisois, 78.
Warne, 83.
White Burley, 82.
Wongbok, 143.

Y

Yatab, 235.
YONZON, E. C., *see* ADRIANO, VALENZUELA, YONZON, and RAMOS.